Section 220518
Escutcheons For Plumbing Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.

2. Floor Plates

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Bare Piping split-casting at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or brass type with polished, chrome-plated finish.
c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

C. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518

Section 220523
General-Duty Valves For Plumbing Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following general-duty valves:
   1. Copper-alloy ball valves.
   2. Ferrous-alloy ball valves.

B. Related Sections include the following:
   1. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and charts.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

B. ASME Compliance:

   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.

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

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.

3. Set gate valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.6 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal.

2.2 VALVES, GENERAL

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

B. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

C. Valve Actuators:

1. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.

2. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

D. Extended Valve Stems: On insulated valves.

E. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

F. Valve Grooved Ends: AWWA C606.

1. Solder Joint: With sockets according to ASME B16.18.

a. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.

2. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BALL VALVES

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

a. NIBCO INC.
b. Apollo
c. Watts

B. Ball valves 2" and smaller: On “L” copper tubing used for water systems, valves shall be regular port two piece, lead free, Bronze ball valve. Watts. #LFB6080G2 bronze body, stainless steel ball, teflon seats and stuffing box ring, lever handle, solder ends.

2.4 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

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

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

2.5 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

2.6 JOINT CONSTRUCTION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

2.7 ADJUSTING

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

B. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, or gate valves.
2. Throttling Service: Globe valves.

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

END OF SECTION 220523

Section 220529
Hangers And Supports For Plumbing Piping And Equipment

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Architectural Documents for information and direction relating to “under slab grid system” that is provided for hanging of plumbing, mechanical, electrical piping, conduits, ducts, etc.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
   Fastener systems.

B. Related Sections:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 22 Section "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7

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

1.5 SUBMITTALS

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

B. Shop Drawings: fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.

1.6 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel

2.2 TRAPEZE PIPE HANGERS

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

2.3 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated stainless- steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.4 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

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

E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

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

G. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

J. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

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

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.3 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches

3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.

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

3.5 HANGER AND SUPPORT SCHEDULE

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

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

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

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

H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
5. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
7. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.

8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
2. C-Clamps (MSS Type 23): For structural shapes.
3. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
4. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
5. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel saddles and shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

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

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

END OF SECTION 220529

Section 220553
Identification For Plumbing Piping And Equipment

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Warning signs and labels.
   2. Pipe labels.
   3. Stencils.
   4. Valve tags.

1.3 SUBMITTALS

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

B. Valve numbering scheme.

C. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.1 PIPE IDENTIFICATION

A. Provide vinyl cloth identification bands, as manufactured by the William K. Brady Company, or "SNAP-A-ROUND" identification bands as manufactured by Seton Name Plate Corporation, or other acceptable manufacturers on all piping. Bands shall not be installed on exposed piping until final painting of the piping has been completed. Band shall indicate the piping service and the direction of flow in each pipe.

B. Install bands on each side of each partition, at each valve, at each change in direction, but in no case shall the bands be more than 25 feet apart on horizontal piping.

C. On vertical piping, the bands shall be located at each floor, at a height of approximately 5'-0" above the floor.

D. Markers or bands shall have background colors similar to ANSI A-13.1 color code and OSHA safety color regulation. In lieu of bands on concealed piping, the piping may, except where contrary to local laws, be painted with 6" bands around the pipe.

2.12 CHARTS AND TAGS

A. Install on each valve a brass tag giving the number of that particular valve and the words “Hot,” “Circ,” “Cold,” or “Gas” thereon. Tags shall be stamped to indicate piping system and shall be 2" diameter with white number 1/2" high and the letters 1/4” high. They shall be attached with a heavy brass "S" hook and a piece of brass window sash chain.

B. Install where directed by the Architect a chart and diagram giving the location and function of each numbered main and riser valve. The chart shall be glass covered in a proper size frame. Valve charts shall be submitted for review prior to framing.

C. Furnish three copies of valve schedule in loose leaf form with acetate covers. Schedule shall be divided into systems and each valve numbered within the systems shall be listed therein and the specific use shall be described. Furnish a key plan for each floor showing the valve locations.

PART 3 - EXECUTION

3.1 PREPARATION

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

END OF SECTION 220553

Section 220719
Plumbing Piping Insulation

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic hot -water return piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties, equipment connections, and access panels.
5. Detail application of field-applied jackets.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Fiber Glass Pipe Insulation: High performance fiber glass, rigid, one –piece insulation, ASJ SSL (All Service Jacket with Self-Sealing Lap Closure System).

1. All referenced manufactures on the construction drawings are to establish a minimum acceptable level of quality and is not intended to prevent submission of equivalent equipment or other materials. Refer to Pipe Insulation Schedule on drawing P0.1.

a. Johns Manville; Micro-Lok HP
b. Approved Equal.

2.2 PVC INSULATED FITTING COVERS

A. PVC Insulated Fitting Covers: High-impact, gloss white, UV-resistant, polyvinyl chloride.

1. All referenced manufactures on the construction drawings are to establish a minimum acceptable level of quality and is not intended to prevent submission of equivalent equipment or other materials.

a. Johns Manville; Zeston 2000 PVC
b. Approved Equal.

2.3 TAPES

A. PVC Tape: Flexible polyvinyl chloride film adhesive tape

1. All referenced manufactures on the construction drawings are to establish a minimum acceptable level of quality and is not intended to prevent submission of equivalent equipment or other materials.

a. Johns Manville; PVC “Z” tape.
b. Approved Equal.

2. Width: 2 inches (51 mm).
3. Thickness: 10 mils (0.25 mm).
4. Adhesion: 30 ounces force/inch (0.033 N/mm) in width.
5. Elongation: 200 percent.
6. Tensile Strength: 27 lbf/inch (4.7 N/mm) in width.

2.4 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers,

1. Manufacturers: Subject to compliance with requirements, provide products available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

a. McGuire Manufacturing.
b. Plumberex.
c. Truebro; a brand of IPS Corporation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

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

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit.

Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two locations of straight pipe, two locations of fittings,

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified in Domestic Water Piping Notes on drawing P02. for each pipe size range Piping insulation schedules in first three articles below specify commonly used insulation materials and thicknesses by pipe size range for each service. LEED Prerequisite EA 2 requires that pipe insulation thickness comply with ASHRAE/IESNA 90.1 table titled "Minimum Pipe Insulation Thickness." Not all materials and thicknesses may be suitable for a specific project. Revise to suit Project after considering all parameters that impact selection. Do not duplicate requirements inserted in "Insulation Materials" Article. See Evaluations for more information and guidance.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot & Cold Water:

a. Cellular Glass; 1” inch thick: pipe 1/2” TO 2” inches.

b. Cellular Glass; 1 1/2” inch thick: Pipe 2 ½” to 4” inches.

B. Domestic Hot Water Return:

a. Cellular Glass; ½” inch thick: pipe 1/2” TO 1 1/2” inches.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

END OF SECTION 220719

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Section 221116
Domestic Water Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Aboveground domestic water pipes, tubes, fittings, and specialties inside the building.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7

1.4 SUBMITTALS

A. Product Data: For the following products:

1. Specialty valves.
2. Transition fittings.
3. Dielectric fittings.
4. Flexible connectors.

B. Coordination Drawings: For piping in congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Domestic water piping.
2. Gas piping.

C. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.5 QUALITY ASSURANCE

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

B. Comply with NSF 61 for potable domestic water piping and components.

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
5. Copper Pressure-Seal-Joint Fittings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

        1) Elkhart Products Corporation; Industrial Division.
        2) NIBCO INC.
        3) Viega; Plumbing and Heating Systems.

    b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
    c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

        1) NVent LLC.

6. Copper-Tube Extruded-Tee Connections:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

        1) T-DRILL Industries Inc.

    b. Description: Tee formed in copper tube according to ASTM F 2014.

7. Compact-Pattern, Push-on-Joint Fittings: AWWA C153, ductile iron.

a. Gaskets: AWWA C111, rubber.

2.3 PIPING JOINING MATERIALS

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

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

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

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

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

G. Install piping to permit valve servicing.

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

I. Install piping free of sags and bends.

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

K. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

L. Install thermostats in hot-water circulation piping.

M. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

P. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties.

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

3.2 JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

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

3.3 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 3 and smaller. gate valves for piping NPS 4 and larger.

C. Install drain valves at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install calibrated balancing valves in each hot-water circulation return branch. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. NPS 1-1/2 and Smaller: Fitting-type coupling.
2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.

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

3.6 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

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

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

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

F. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.8 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
1. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.9 IDENTIFICATION

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

B. Label pressure piping with system operating pressure.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

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

E. Prepare test and inspection reports.

3.11 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.12 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

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

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.13 PIPING SCHEDULE

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

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

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Aboveground domestic water piping, shall be::
Hard copper tube, ASTM B 88, Type L; wrought- copper solder-joint fittings; and soldered joints.

3.14 VALVE SCHEDULE

1. Shutoff Duty: Use ball or gate valves for piping NPS 3 and smaller. Use, gate valves with flanged ends for piping NPS 4 and larger.
2. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
3. Drain Duty: Hose-end drain valves.

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

END OF SECTION 221116

Section 221119
Domestic Water Piping Specialties

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Vacuum breakers.
2. Backflow preventers.
3. Balancing valves.
4. Temperature-actuated water mixing valves.
5. Hose bibbs.
6. Drain valves.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. NSF Compliance:
1. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers <Insert drawing designation if any>:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Cash Acme.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Watts Industries, Inc.; Water Products Div.
      e. Zurn Plumbing Products Group; Wilkins Div.

   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Body: Bronze.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Rough bronze Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
      a. Conbraco Industries, Inc.
      b. MIFAB, Inc.
      c. Watts Industries, Inc.; Water Products Div.
      d. Woodford Manufacturing Company.
      e. Zurn Plumbing Products Group; Light Commercial Operation.

   2. Standard: ASSE 1011.
   3. Body: Bronze, nonremovable, with manual drain.
   4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
   5. Finish: Chrome or nickel plated Rough bronze.

2.2 BACKFLOW PREVENTERS

A. Dual-Check-Valve Backflow Preventers >:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

      a. Cash Acme.
      b. Watts Industries, Inc.; Water Products Div.

   2. Standard: ASSE 1032.
   3. Operation: Continuous-pressure applications.
   4. Size: NPS 1/4 or NPS 3/8.
   5. Body: Stainless steel.
   6. End Connections: Threaded.

B. Hose-Connection Backflow Preventers

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

    a. Conbraco Industries, Inc.
    b. Watts Industries, Inc.; Water Products Div.
    c. Woodford Manufacturing Company.

2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 1/2 or NPS 3/4
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

2.3 BALANCING VALVES

A. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Memory-Stop Balancing Valves
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Conbraco Industries, Inc.
    b. Crane Co.; Crane Valve Group; Stockham Div.
    c. Milwaukee Valve Company.
    d. NIBCO INC.
    e. Red-White Valve Corp.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.4 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Individual-Fixture, Water Tempering Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
    a. Conbraco Industries, Inc.
    b. Honeywell Water Controls.
    c. Powers; a Watts Industries Co.
    d. Watts Industries, Inc.; Water Products Div.
    e. Lawler Manufacturing

2. Standard: ASSE 1016, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.

6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.
8. Tempered-Water Setting: 120 degree
9. Tempered-Water Design Flow Rate: 2 GPM

B. Mixing valve shall be Lawler series 310 or equal

2.5 HOSE BIBBS

A. Hose Bibbs

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

   a. Chicago
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Watts Drainage Products Inc.
   e. Woodford Manufacturing Company.
   f. Zurn Plumbing Products Group

2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig
8. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Finished Rooms: Chrome or nickel plated.
10. Operation for Finished Rooms: Operating key.
11. Include operating key with each operating-key hose bibb.
12. Include wall flange with each chrome- or nickel-plated hose bibb.
    Size: NPS 3/4

B. Hose Bibb shall be similar to Chicago 387-E27CP

2.6 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

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

C. Install water control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install thermometers and water regulators if specified.

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

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Double-check, backflow-prevention assemblies.
4. Primary water tempering valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

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

3.5 ADJUSTING

A. Set field-adjustable flow set points of balancing valves.

B. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 221119

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Section 221316
Sanitary Waste And Vent Piping

PART 1 - GENERAL

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

1.2 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.

1.3 PERFORMANCE REQUIREMENTS

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

1. Soil, Waste, and Vent Piping: 10-foot head of water

2. SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. For Manufacturer of Cast Iron Soil Pipe and Fittings: Member of the Cast Iron Soil Pipe Institute (CISPI).

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

1. Cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and NSF.

C. Cast iron pipe and fittings shall be certified by NSF, subject to CISPI quality control program and complying with International Plumbing Code.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the specified product, or a comparable product by one of the manufacturers listed.

2.2 PIPING MATERIALS

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

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74 Service class or CISPI 301

   1. Basis-of-Design Product: Subject to compliance with requirements, provide Charlotte Pipe and Foundry Co.; "Charlotte Service" or a comparable product by one of the following:

      a. ANACO-Husky.
      b. Clamp-All Corp.
      c. MIFAB, Inc

B. Heavy-Duty, Hubless-Piping Couplings:

   1. Heavy-Duty, Shielded, Stainless-Steel Couplings: ASTM C 1540, with stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

   2. Basis-of-Design Product: Subject to compliance with requirements, provide Charlotte Pipe and Foundry Co.; "Charlotte Service" or a comparable product by one of the following:

      a. ANACO-Husky.
      b. Clamp-All Corp.
      c. MIFAB, Inc.

   3. Standards: ASTM C 1277 and ASTM C 1540.
   4. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Drainage Piping: 1 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

N. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."
2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."

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

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steelpipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

   Longer Than 100 Feet MSS Type 43, adjustable roller hangers.
5. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

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

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

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

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. Spacing for 10-foot lengths may be increased to 10 feet Spacing for fittings is limited to 60 inches .

F. Install supports for vertical cast-iron soil piping every 15 feet.

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

3.4 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.5 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.6 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water . From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.7 CLEANING AND PROTECTION

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

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.8 PIPING SCHEDULE

A. Aboveground, soil and waste piping be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.

B. Aboveground, vent piping shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; [CISPI] hubless-piping couplings; and coupled joints.

END OF SECTION 221316

Section 221319
Sanitary Waste Piping Specialties

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains
   3. Sanitary Indirect Waste Drains

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

1.3 COORDINATION

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

B. Coordinate size and location of roof penetrations.

1.4 MANUFACTURERS

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

1. Jay R Smith
2. Wade
3. Mifab

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Cleanouts in waterproofed floors shall be made accessible through a modified, J. R. Smith 4313, Wade W-8190, or Zurn ZN 1455-4C with flashing clamp and 6 lb. lead flashing. Flashing shall be extended at least 12" beyond drain body in all directions. Cover of cleanout shall be nickel bronze or recessed to receive asphalt tiles, Zurn ZN 1455-5C.

B. Cleanouts behind walls shall be extended to finished wall and closed gas tight with bronze plug and stainless steel cover similar to J. R. Smith 4422 or 4472, Wade W-8450-R or W-8470-R, or Zurn ZN 1440-1 in cast iron pipe or Fig. ZN 1460-8 in steel pipe. Cleanout plugs shall be made up with a graphite lubricant or teflon tape to insure easy removal. No pipe compound shall be used on cleanouts. Cleanout covers shall have no lettering on the finished surface.

2.2 FLOOR DRAINS

Type A: (Toilet Room) shall be cast iron with double drainage flange and seepage openings, bottom outlet connection, flashing clamp device, and 6" round adjustable strainer of high polished brass or bronze. Individual shower compartments use a 6" round adjustable strainer of high polished nickel bronze. Drains shall be Smith 2005Y-A, or equal MIFAB F1000C.

Type B: Kitchen Floor Sink Funnel Drain : Zurn Z326-AR-DB, 7” diameter indirect waste funnel acid resisting epoxy coated cats iron with bottom dome strainer.

Type C: (Kitchen Floor Drain) shall be Smith 3141Y -Drain shall be cast-iron with acid resistant coated interior and exterior, bottom outlet, flashing collar, adjustable nickel bronze top and full bar grate with sediment bucket.

Type D: (Kitchen Sanitary Indirect Waste Drain). Drain shall consist of a cast iron body witha white acid – resisting coating and a PVC anti splash dome strainer. Drain shall be Zurn No-Hub type Model FD2378 Series 8”x8” x6” deep.

2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

    a. NPS 2: 4-inch- minimum water seal.
    b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

B. Air-Gap Fittings

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

C. Sleeve Flashing Device

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top

of fitting that will extend 1 inch 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.

2. Size: As required for close fit to riser or stack piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

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

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

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

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

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

E. Install deep-seal traps on floor drains and other waste outlets, if indicated.

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

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

H. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 TESTS

A. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in the sanitary piping . If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg . Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

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

END OF SECTION 221319

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Section 22 34 00
Fuel-Fired, Domestic-Water Heaters

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Commercial, power condensing, gas-fired, water heaters.
2. Water heater accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. LEED Submittals:

1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1, Section 7, "Service Water Heating."

C. Shop Drawings:

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

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fuel-fired, domestic-water heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of commercial gas-fired water heater from manufacturer.

C. Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Listing: The water heater will be listed ETL listed to UL 795 or ANSI Z21.10.3 -2004/CSA 4.3-2004 “Gas Water Heaters”

B. ASME Compliance: Water heater shall bear the ASME HLW stamp and be National Board listed

C. The water heater will operate at a minimum 95% thermal efficiency at full firing rate when tested to the ANSI Z21.10.3 thermal efficiency test protocol.

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

E. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.

F. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

G. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.7 COORDINATION

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

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:

3. Storage Tank: 15-year coverage (8 years full, 7 additional years of discounted replacement) for manufacturing or material defects, leaks, production of rusty or discolored water and/or chloride stress corrosion cracking.

4. The heater shall have a first year service policy, which shall cover labor and freight costs under certain conditions for warranty covered services.

5. Burner and all heater parts: two years

PART 2 - PRODUCTS

A. The heater shall have a first year service policy, which shall cover labor and freight costs under certain conditions for warranty covered services. Commercial, Gas-Fired, Power Condensing Domestic-Water Heaters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following or approved equal:

a. PVI Industries, LLC.
b. Bradford White Corporation.
c. Lochinvar Corporation.

2. Standard: ANSI Z21.10.3/CSA 4.3.
3. Description: Manufacturer's proprietary design to provide at least 99.1% Ultra High Efficiency.

4. Factory-Installed Storage-Tank Appurtenances:

B. The water heater will be a vertical fire tube design that is constructed and stamped in accordance with Section IV, Part HLW of the ASME code. Water heater will be National Board Registered for a working pressure of 150 psi and will be pressure tested at 1-1/2 times working pressure.

C. Water heater will be a three-pass configuration

D. Tank and fire tubes will be unlined. Lined or plated water heaters will not be acceptable

E. Tank and fire tubes will be constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21% chromium to prevent corrosion and mill certified per ASTM A 923Methods A to ensure that the product is free of detrimental chemical precipitation that affects corrosion resistance. The material selected shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2and ASTM G123 - 00(2005) “Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution.”

F. Waterside surfaces shall be welded internally utilizing joint designs to minimize volume of weld deposit and heat input. All heat affected zones (HAZ) shall be processed after welding to ensure the HAZ corrosion resistance is consistent with the mill condition base metal chemical composition. Weld procedures (amperage, volts, welding speed, filler metals and shielding gases) utilized shall result in a narrow range of austenite-ferrite microstructure content consistent with phase balanced objectives for welds, HAZ and the base metal.

G. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces. Other passivation and pickling methods are not accepted. Immersion passivation and pickling certification documents are required and shall be provided with each product.

H. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems. Storage tank materials shall contain more than 80% post-consumer recycled materials and be 100% recyclable.

I. Water contacting tank surfaces will be non-porous and exhibit 0% water absorption.

J. All tank connections/fittings will be non-ferrous.

K. Finished vessel will not require sacrificial anode rods and none will be used. Water heaters or sidearm storage tanks that employ anode rods of any type will not be acceptable.

L. Combustion will be provided by a premix, fan-assisted surface burner with a gas train meeting ANSI and FM requirements for the input specified.

M. Burner will be stainless steel covered with stainless steel mesh

N. Burner will employ non-linkage modulation utilizing only a VFD drive to vary gas and air.

O. Burner NOx emissions will be less than 20 ppm when corrected to 3% oxygen.

P. Water heater will be a category IV, condensing appliance and vent through CPVC

Q. Capacity and Characteristics:

1. Capacity: 250 gal.
2. Recovery: 2085 gph at 140 deg F temperature rise.
3. Fuel Gas Input: 1,800,000 Btu/h.

4. Electrical Characteristics:

   a. Volts: 120
   b. Phase: Single
   c. Hertz: 60.

5. Vent Diameter: 8” based on intake and exhaust

2.2 WATER HEATER ACCESSORIES

A. Water Compression Tanks:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. AMTROL Inc.
b. Flexcon Industries.
c. State Industries.

2. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:

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

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and [calibrated] [memory-stop] balancing valves to provide balanced flow through each domestic-water heater.

1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
2. Comply with requirements for balancing valves specified in Division 22 Section "Domestic Water Piping Specialties."

F. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.

G. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include pressure rating as required to match gas supply.

H. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.

I. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.

J. Pressure Relief Valves: Include pressure setting less than domestic-water heater working-pressure rating.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.

K. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters and storage tanks to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Division 01 Section "Quality Requirements" for retesting and reinspecting requirements and Division 01 Section "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete, Miscellaneous Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Install gas-fired, Water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Division 23 Section "Facility Natural-Gas Gas Piping."

C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Division 22 Section "Domestic Water Piping Specialties."

F. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Division 22 Section "Meters and Gages for Plumbing Piping."

G. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet. Comply with requirements for valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping," and comply with requirements for thermometers specified in Division 22 Section "Meters and Gages for Plumbing Piping."

H. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.

I. Fill domestic-water heaters with water.

J. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Division 22 Section "Domestic Water Piping."

B. Comply with requirements for fuel-oil piping specified in Division 23 Section "Facility Fuel-Oil Piping."

C. Comply with requirements for gas piping specified in Division 23 Section "Facility Natural-Gas Piping."

D. Drawings indicate general arrangement of piping, fittings, and specialties.

E. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Division 01 Section "Quality Requirements" for retesting and reinspecting requirements and Division 01 Section "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION 223400

Section 224000
Plumbing Fixtures

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions", "Special Requirements" and "General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:

1. Faucets for lavatories.
2. Flushometers.
3. Toilet seats.
4. Fixture supports.
5. Water closets.
6. Lavatories.
7. Urinals.

B. Related Sections include the following:

1. Division 22 Section "Domestic Water Piping Specialties" for floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

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

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

E. FRP: Fiberglass-reinforced plastic.

F. PMMA: Polymethyl methacrylate (acrylic) plastic.

G. PVC: Polyvinyl chloride plastic.

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

1.4 SUBMITTALS

A. All Submittals shall be coordinated and scheduled in accordance with the DGS bidding documents.

B. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

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

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act" for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

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

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Vitreous-China Fixtures: ASME A112.19.2M.
2. Water-Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory faucets:
1. Faucets: ASME A112.18.1.
2. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
3. NSF Potable-Water Materials: NSF 61.
4. Pipe Threads: ASME B1.20.1.
5. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
6. Supply Fittings: ASME A112.18.1.
7. Brass Waste Fittings: ASME A112.18.2.

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

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Plastic Tubular Fittings: ASTM F 409.

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

1. Floor Drains: ASME A112.6.3.
2. Grab Bars: ASTM F 446.
3. Off-Floor Fixture Supports: ASME A112.6.1M.
4. Pipe Threads: ASME B1.20.1.
5. Plastic Shower Receptors: ANSI Z124.2.
6. Plastic Toilet Seats: ANSI Z124.5.
7. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Structural failures of unit shell.
   b. Faulty operation of flushometers, faucets, fixtures and valves.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

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

   a. Chicago Faucets
   b. T&S Brass and Bronze Works
   c. Approved Equal.

2.2 FLUSHOMETERS

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

   a. Sloan Valve Company
   b. Zurn Industries

c. Approved Equal.

2.3 TOILET SEATS

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

   a. Church #9500C, open front without cover, white in color.
   b. Olsonite #95, open front without cover, white in color.
   c. Approved Equal.

2.4 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

   a. McGuire Manufacturing Co., Inc.
   b. TRUEBRO, Inc.
   c. Approved Equal.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures,

C. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of first two subparagraphs and list of manufacturers below. See Division 01 Section "Product Requirements."

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

   a. TRUEBRO, Inc.
   b. McGuire Manufacturing Co., Inc.
   c. Approved Equal

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.5 FIXTURE SUPPORTS

A. Lavatory Supports

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

    a. Smith, Jay R. Mfg. Co.
    b. Josam Co.
    c. Approved equal

B. Urinal Supports

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

    a. Smith, Jay R. Mfg. Co.
    b. Josam Co.
    c. Approved equal

2.6 WATER CLOSETS

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

    a. American Standard
    b. Eljer.
    c. Kohler Co.
    d. Approved Equal.

B. Description wall mounting, blow out wall hung top spud.

    a. Type: Siphon jet: floor mounted top spud
    b. Strainer or trapway: open trapway
    c. Design consumption; 1.28 gpf
    d. Color: white
    e. Supply Spud size: 1 ½ HPS
    f. Outlet size: 4”
    g. Drain piping: 4”
    h. Flushometer: See dwg. P001
    i. Fixture support: See dwg. P001

2.7 LAVATORIES

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

    a. American Standard
    b. Ekay
    c. Just Manufacturing Co.
    d. Approved Equal.

B. Description wall mounting

a. Type: wall mounted
b. Strainer or trapway: open trapway
c. Design consumption: .35 GPM
d. Color: white
e. Spud size: ½" HPS
f. Outlet size: 1 ¼"
g. Drain piping: 1 ¼"
h. Flushometer: See dwg. P001
i. Fixture support: See dwg. P001

2.8 MOP SINK

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

a. Elkay
b. Just Manufacturing Co.
c. Approved Equal.

2.9 URINALS

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

a. American Standard
b. Eljer.
c. Kohler Co.
d. Approved Equal.

B. Description Wall mounting, bottom-outlet, vitreous-china fixture designed for flushometer valve operation.

a. Type: Washout.
b. Strainer or Trapway: Open trapway.
c. Design Consumption: .05 OGL/flush (GPF).
d. Color: White.
e. Supply Spud Size: NPS 3/4 (DN 20) (back spud).
f. Outlet Size: NPS 2.
g. Drain Piping: NPS 2.
h. Flushometer: See dwg. P001
i. Fixture Support: See dwg. P001

2.10 ELECTRIC WATER COOLER

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

a. Elkay
b. Haws
c. Approved equal

B. Description wall mounting

a. AOA bottle filling station
b. Strainer or trapway: Open trapway
c. Design Consumption: Chill capacity 8.GPH
d. Color: 5.5
e. Supply size: ½”
f. Outlet size: 1 ¼” HPS
g. Drain piping: HPS 1 ¼”
h. Flushometer: See dwg. P001
i. Fixture support: See dwg. P001

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

C. Install wall-mounting fixtures with tubular waste piping attached to supports.

D. Install fixtures level and plumb according to roughing-in drawings.

E. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture.

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

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

H. Install toilet seats on water closets.

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

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

K. Install traps on fixture outlets.

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

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

M. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Professional.

END OF SECTION 224000

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Section 231123
Natural-Gas Piping

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions", "Special Requirements" and "General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.5 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

1.6 SUBMITTALS

A. All Submittals shall be coordinated and scheduled in accordance with the DGS bidding documents.

B. Product Data: For each type of the following:

1. Piping specialties.
2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Dielectric fittings.

C. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4 inch per foot.

D. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

E. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

F. Welding certificates.

G. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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

1.8 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.9 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

1.10 COORDINATION

A. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

        1) Dresser Piping Specialties; Division of Dresser, Inc.
        2) Smith-Blair, Inc.

    b. Stainless-steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.
    d. Stainless-steel bolts, washers, and nuts.
    e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. PE Pipe: ASTM D 2513, SDR 11. (PE site distribution piping installed by PECO, PVC conduit for PECO PE site distribution piping and warning tape installed by site contractor)

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
    b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
    c. Aboveground Portion: PE transition fitting.
    d. Outlet shall be threaded or flanged or suitable for welded connection.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
    b. Outlet shall be threaded or flanged or suitable for welded connection.
    c. Bridging sleeve over mechanical coupling.
    d. Factory-connected anode.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

5. Plastic Mechanical Couplings, NPS 1-1/2 and Smaller: Capable of joining PE pipe to PE pipe.

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

        1) Lyall, R. W. & Company, Inc.
        2) Mueller Co.; Gas Products Div.
        3) Perfection Corporation; a subsidiary of American Meter Company.

    b. PE body with molded-in, stainless-steel support ring.
    c. Buna-nitrile seals.
    d. Acetal collets.
    e. Electro-zinc-plated steel stiffener.

6. Plastic Mechanical Couplings, NPS 2 and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

1) Lyall, R. W. & Company, Inc.
2) Mueller Co.; Gas Products Div.
3) Perfection Corporation; a subsidiary of American Meter Company.

b. Fiber-reinforced plastic body.
c. PE body tube.
d. Buna-nitrile seals.
e. Acetal collets.
f. Stainless-steel bolts, nuts, and washers.

7. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

1) Dresser Piping Specialties; Division of Dresser, Inc.
2) Smith-Blair, Inc.

b. Stainless-steel flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. Stainless-steel bolts, washers, and nuts.
e. Factory-installed anode for steel-body couplings installed underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors (gas furnace on AHU-1 only):

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Corrugated stainless-steel tubing with polymer coating.
3. Operating-Pressure Rating: 0.5 psig.
4. End Fittings: Zinc-coated steel.
5. Threaded Ends: Comply with ASME B1.20.1.
6. Maximum Length: 36 inches.

B. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

    a. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

    a. Lee Brass Company.
    b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

    a. McDonald, A. Y. Mfg. Co.
    b. Mueller Co.; Gas Products Div.
    c. Xomox Corporation; a Crane company.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

    a. McDonald, A. Y. Mfg. Co.
    b. Milliken Valve Company.
    c. Mueller Co.; Gas Products Div.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. PE Ball Valves: Comply with ASME B16.40.

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

    a. Kerotest Manufacturing Corp.
    b. Lyall, R. W. & Company, Inc.
    c. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: PE.
3. Ball: PE.
4. Stem: Acetal.
5. Seats and Seals: Nitrile.
6. Ends: Plain or fusible to match piping.
7. CWP Rating: 80 psig.
8. Operating Temperature: Minus 20 to plus 140 deg F.
9. Operator: Nut or flat head for key operation.
10. Include plastic valve extension.
11. Include tamperproof locking feature for valves where indicated on Drawings.

I. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 DIELECTRIC FITTINGS

A. Dielectric Unions:

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

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Hart Industries International, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
    f. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.

5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

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

   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   d. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

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

   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.6 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the 2006 International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the 2006 International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with the 2006 International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 26 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

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

E. Install pressure gage tap upstream and downstream from each service regulator.

3.4 INDOOR PIPING INSTALLATION

A. Comply with the 2015 International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

4. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage taps upstream and downstream from each line regulator.

W. Install sleeves for piping penetrations of walls, ceilings, and floors.

X. Install sleeve seals for piping penetrations of concrete walls and slabs.

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. Service-meter and regulator assembly installation is by PECO.

B. Install dielectric fittings downstream from service meters.

C. Install metal bollards to protect meter assemblies.

3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance. Install ahead of flexible gas connector on AHU-1.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.

2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.8 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "Identification for HVAC Equipment" for identification. Paint interior concealed and exposed natural gas piping yellow and install pipe identification labels every 15 feet.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.11 PAINTING

A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
c. Topcoat: Exterior alkyd enamel semigloss.
d. Color: Gray.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI INT 5.1E.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Interior alkyd matching topcoat.
c. Topcoat: Interior alkyd (semigloss).
d. Color: yellow.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the 2006 International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Department's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.14 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

B. Aboveground natural-gas piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:

1. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of] the following:

1. Cast-iron, lubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Bronze plug valve.
2. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 231123

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Section 23 05 00
Basic Mechanical Materials And Methods

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Mechanical demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

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

F. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.

4. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

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

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
1. Manufacturers Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

a. Calpico, Inc.

b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.5 MECHANICAL SLEEVE SEALS

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

1. Manufacturers Subject to compliance with requirements, provide products by the manufacturers specified or approved equal.

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 SLEEVES

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

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

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

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

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.7 ESCUTCHEONS

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

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

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

1. Finish: Polished chrome-plated and rough brass.

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

1. Finish: Polished chrome-plated and rough brass.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.

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

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

2.8 GROUT

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

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

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

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

1. New Piping:

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

2. Existing Piping: Use the following:

    a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
    b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and spring clips.

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

M. Sleeves are not required for core-drilled holes.

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

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

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

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

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

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

    a. PVC Steel Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.

        1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.

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

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

T. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

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

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

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

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

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

3.5 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section " Cast-in-Place Concrete (Limited Applications)."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 230500

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Section 230513
Common Motor Requirements For Hvac Equipment

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

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

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Variable speed drives
3. Torque, speed, and horsepower requirements of the load.
4. Ratings and characteristics of supply circuit and required control sequence.
5. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

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

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

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

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

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

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

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Section 230516
Expansion Fittings And Loops For Hvac Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. Section Includes:
   1. Alignment guides and anchors.
   2. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

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

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.2 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

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Section 230519
Meters And Gages For Hvac Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Duct thermometer mounting brackets.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Orifice flowmeters.
9. Vortex-shedding flowmeters.
10. Impeller-turbine, thermal-energy meters.
11. Ultrasonic, thermal-energy meters.

1.3 ACTION SUBMITTALS

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

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

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

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

1. Trerice, H. O. Co.
2. Weiss Instruments, Inc.
3. Weksler

B. Standard: ASME B40.200.

C. Case: Liquid-filled type(s); stainless steel with 3-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.

E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass or plastic.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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

a. Trerice, H. O. Co.
b. Weiss Instruments, Inc.
c. Weksler

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.

8. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

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

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Trerice, H. O. Co.
    d. Weiss Instruments, Inc. Standard:

2. ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

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

1. Flow Design, Inc.
2. Peterson Equipment Co., Inc.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

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

F. Core Inserts: EPDM self-sealing rubber.

2.8 FLOWMETERS

A. Orifice Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Dwyer Instruments, Inc.
b. Emerson Process Management, Rosemount, Inc.
c. Spirax Sarco

2. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.

3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.

    a. Design: Differential-pressure-type measurement for water.
    b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
    c. Minimum Pressure Rating: 300 psig.
    d. Minimum Temperature Rating: 250 deg F.

5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch-diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.

    a. Scale: Gallons per minute.
    b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two 12-foot hoses, with carrying case.

    a. Scale: Gallons per minute.
    b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.

7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Conversion Chart: Flow rate data compatible with sensor and indicator.
9. Operating Instructions: Include complete instructions with each flowmeter.

B. Vortex-Shedding Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

    a. Dwyer Instruments, Inc.
    b. Emerson Process Management, Rosemount, Inc.
    c. Spirax Sarco

2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute.

    a. Design: Flow obstruction device, vortex-measurement type for steam.
    b. Construction: Stainless-steel body, with integral transmitter and direct-reading scale.
    c. Minimum Pressure Rating: 1000 psig.
    d. Minimum Temperature Rating: 500 deg F.
    e. Integral Transformer: For low-voltage power operation.

5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus or minus 0.25 percent for liquids and 0.75 percent for gases.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

2.9 THERMAL-ENERGY METERS

A. Impeller-Turbine, Thermal-Energy Meters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Dwyer Instruments, Inc.
b. Emerson Process Management, Rosemount, Inc.
c. Spirax Sarco

2. Description: System with strainer, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.

a. Design: Total thermal-energy measurement.
b. Minimum Pressure Rating: 150 psig.
~~c.~~ Minimum Temperature Range: 40 to 350 deg F~~.~~

4. Temperature Sensors: Insertion-type transducer.
5. Indicator: Solid-state, integrating-type meter with integral battery pack; for wall mounting.

a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
b. Battery Pack: Five-year lithium battery.

6. Accuracy: Plus or minus 1 percent.
7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
8. Strainer: Full size of main line piping.
9. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be the following:
   1. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
   1. Industrial-style, liquid-in-glass type.

C. Thermometers at inlets and outlets of each chiller shall be the following:
   1. Industrial-style, liquid-in-glass type.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:

   1. Industrial-style, liquid-in-glass type.

E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be the following:
   1. Industrial-style, liquid-in-glass type.

F. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be the following:

   1. Liquid-filled, bimetallic-actuated type.

G. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Condenser-Water Piping: 0 to 150 deg F.

C. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

D. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

E. Scale Range for Air Ducts: 0 to 150 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be the following:

1. Liquid-filled, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be the following:

1. Liquid-filled, direct-mounted, metal case.

C. Pressure gages at suction and discharge of each boiler shall be the following:

1. Liquid-filled, direct-mounted, metal case.

D. Pressure gages at suction and discharge of each pump shall be the following:

1. Liquid-filled, direct-mounted, metal case.

E. Pressure gages at inlet and outlet of each hydronic coil shall be the following:

1. Liquid-filled, direct-mounted, metal case.
2. Test plug with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Condenser-Water Piping: 0 to 100 psi.

B. Scale Range for Low Pressure Steam Piping: 0 to 30 psi.

C. Scale Range for High Pressure Steam Piping: 0 to 160 psi.

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Orifice type.

B. Flowmeters for Condenser-Water Piping: Orifice type.

C. Flowmeters for Heating, Hot-Water Piping: Orifice type.

D. Flowmeters for Steam and Steam-Condensate Piping: Vortex-shedding type.

3.9 THERMAL-ENERGY METER SCHEDULE

A. Thermal-Energy Meters for Chilled-Water Piping: Impeller-turbine type.

B. Thermal-Energy Meters for Heating, Hot-Water Piping: Impeller-turbine type.

C. Thermal-Energy Meters for Steam and Steam-Condensate Piping: Impeller-turbine type.

END OF SECTION 230519

Section 23 05 23
Valves For Hvac Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. Section Includes:

a. Bronze gate valves.

b. Bronze globe valves.

c. Bronze swing check valves.

d. Iron swing check valves.

e. Bronze ball valves.

f. Cast iron plug valves.

g. Iron butterfly valves.

h. Spring loaded lift disc check valves.

i. Calibrated balancing valves.

j. Safety valves.

k. Automatic flow control valves.

l. Electric valve actuators.

m. Chainwheel actuators

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

H. PTFE: Polytetrafluoroethylene plastic.

I. WOG: Water, oil, or gas.

J. TFE: Tetrafluoroethylene plastic

1.4 SUBMITTALS

A. Product Data:

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

2. For each type of special duty valve indicated include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves and automatic flow control valves.

B. Maintenance Data.

1. Furnish maintenance manuals as specified in Division 1.

1. Furnish complete operation and maintenance manuals for the purchased equipment.

2. Include the following items as a minimum for the purchased equipment.

a. Parts list.

b. Maintenance guide.

c. Preventive maintenance schedule.

d. Flow / pressure drop curves.

e. Performance data.

f. Lubrication schedule.

1.5 QUALITY ASSURANCE

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

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. Standards: If any item in this specification, as furnished by the contractor is manufactured in a location which does not certify ASME / ANSI standards, the contractor is to pay the owner for all expenses incurred by the owner for an outside testing company to confirm such compliances.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends. with wooden flange covers or with screwed plugs / caps as required.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.
7. Protect instrumentation from damage.
8. Clean flanges and exposed metal surfaces and treat with anti-corrosive compound before assembly and testing.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points

1.7 WARRANTY

A. General warranty: Special warranty specified in this article shall not deprive the owner of the other rights Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by Contractor under requirements of the Contract Documents.

B. Manufacturer’s warranty: 2 year written warranty signed by manufacturer agreeing to repair or replace all defective items including material, parts and labor at no additional cost to the owner.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule on design documents.

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
6. Electric motor: As indicated on the drawings.

E. Valves in Insulated Piping: With 2-inchstem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves
2. Flanged: With flanges according to ASME B16.5 for steel valves,
3. Flanged: With flanges according to ASME B16.24 for bronze valves.
4. Solder Joint: With sockets according to ASME B16.18.
5. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 VALVE DESCRIPTIONS

A. BRONZE GATE VALVES, 2 INCHES AND SMALLER, MSS SP-80 TYPE 1

1. Manufacturers - Bronze gate valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Crane Co.; Crane Valve Group; Jenkins Valves

b. Crane Co; Crane Valve Group; Crane Valves

c. Crane Co; Crane Valve Group; Stockham Division.

d. Grinnell Corporation

e. Walworth Company

f. NIBCO Inc.

2. Class 150 psi steam, 300 psi cold working pressure (CWP)

a. ASTM B 62 cast-bronze body and bonnet

b. Union bonnet

c. Solid-bronze wedge

d. Copper-silicon alloy rising stem

e. Teflon-impregnated packing with bronze packing nut

f. Aluminum or malleable-iron handwheel

g.

B. BRONZE GLOBE VALVES, 2 INCHES AND SMALLER, MSS SP-80 TYPE 3

1. Manufactures-Bronze globe valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Crane Co; Crane Valve Group; Jenkins Valves

b. Crane Co; Crane Valve Group; Crane Valves

c. Crane Co; Crane Valve Group; Stockham Division.

d. Grinnell Corporation

e. Walworth Company

f. NIBCO Inc.

2. Class 150 psi steam, 300 psi cold working pressure (CWP)

a. ASTM B 62 cast-bronze body and bonnet

b. Union bonnet

c. Stainless steel disc

d. Stainless steel seat

e. Copper-silicon alloy rising stem

f. Teflon-impregnated packing with bronze packing nut

g. Threaded end connection

h. Aluminum or malleable-iron handwheel

C. BRONZE SWING CHECK VALVES, 2 INCHES AND SMALLER, MSS SP-80

1. Manufacturers - Bronze check valves, Horizontal and Vertical - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Horizontal

1) Crane Co.; Crane Valve Group; Jenkins Valves

2) Crane Co.; Crane Valve Group; Crane Valves

3) Crane Co.; Crane Valve Group; Stockham Division

4) Grinnell Corporation

5) Walworth Company

6) NIBCO Inc.

b. Vertical

1) Crane Co.; Crane Valve Group; Jenkins Valves

2) Crane Co.; Crane Valve Group; Crane Valves

3) Cincinnati Valve Co

2. Class 150 psi steam, 300 psi cold working pressure (CWP)

a. ASTM B 62 cast-bronze body and cap
b. “Y” pattern

c. Stainless steel free floating hinge pin

d. Threaded cap

e. Regrinding seat

f. Bronze disc

D. BRONZE BALL VALVES, 3 INCHES AND SMALLER

1. Manufacturers - Bronze ball valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

    a. Conbraco Industries Inc.; Apollo Division

    b. Crane Co.; Crane Valve Group; Jenkins Valves

    c. Crane Co.; Crane Valve Group; Stockham Division

    d. Jamesbury Inc.

    e. Milwaukee Valve Company

2. 2 piece, class 150 psi steam, 600 psi cold working pressure (CWP), reduced port

    a. ASTM B584 cast bronze body

    b. Stainless steel ball and stem

    c. Chrome plated brass ball with brass stem

    d. Blow out proof stem design

    e. PTFE seats

    f. PTFE stem packing

    g. Zinc plated steel lever with vinyl covered grip

3. 2 piece, class 150 psi steam, 600 psi cold working pressure (CWP), standard port

    a. ASTM B584 cast bronze body

    b. Stainless steel ball and stem

    c. Chrome plated brass ball with brass stem

    d. Blow out proof stem design

    e. PTFE seats

    f. PTFE stem packing

    g. Zinc plated steel lever with vinyl covered grip

4. 3 piece, class 150 psi steam, 600 psi cold working pressure (CWP), full port

a. ASTM B584 cast bronze body

b. Stainless steel ball and stem

c. Chrome plated brass ball with brass stem

d. Blow out proof stem design

e. PTFE seats

f. PTFE stem packing

g. Zinc plated steel lever with vinyl covered grip

h. Threaded ends

E. CARBON STEEL BALL VALVES

1. Manufacturers - Steel ball valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Conbraco Industries Inc.; Apollo Division

b. Crane Co.; Crane Valve Group; Stockham Division

c. Jamesbury Inc.

d. Cooper Cameron Corp.; Cooper Cameron Valves Div.

e. Milwaukee Valve Company

2. 2 piece, class 150 psi steam, 3000 psi cold working pressure (CWP), full port, 2_inches and smaller

a. ASTM A108 carbon steel body

b. Stainless steel ball and stem

c. ASTM A108 chrome plated ball and stem

d. Blow out proof stem design

e. PTFE seats

f. PTFE stem packing

g. Zinc plated steel lever with vinyl covered grip

h. Threaded ends

3. 3 piece, class 150 psi steam, 1000 psi cold working pressure (CWP), full port, 2_inches and smaller

    a. ASTM A108 carbon steel body

    b. Stainless steel ball and stem

    c. ASTM A108 chrome plated ball and stem

    d. Blow out proof stem design

    e. PTFE seats

    f. PTFE stem packing

    g. Zinc plated steel lever with vinyl covered grip

4. ANSI flanged, class 150 psi steam, 285 psi cold working pressure (CWP), reduced port, 2½ inches to 10 inches

    a. ASTM A216 WCB cast carbon steel body

    b. ASTM A216 WCB chrome plated ball

    c. ASTM A108 carbon steel stem

    d. Blow out proof stem design

    e. PTFE seats

    f. Graphite stem packing

    g. Galvanized pipe lever

    h. Raised face flange ends

5. ANSI flanged, class 150 psi steam, 285 psi cold working pressure (CWP), full port, 2½ inches to 6 inches

    a. ASTM A216 WCB cast carbon steel body

    b. ASTM A216 WCB chrome plated ball

    c. ASTM A108 carbon steel stem

    d. Blow out proof stem design

    e. PTFE seats

    f. Graphite stem packing

g. Galvanized pipe lever

h. Raised face flange ends

F. CAST IRON PLUG VALVES

1. Manufacturers - Cast iron plug valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Nordstrom Valve Inc.

b. Walworth Company

c. R&M Energy systems (Tomball Tx)

d. Olson Technologies; Homestead Div.

2. 2 inch and smaller, MSS SP 25, MSS SP-78

a. 200 psi cold working pressure (CWP)

1) ASTM A 126 gray iron body

2) Regular pattern

3) Screwed gland

4) Buna-N gland and stem seals

5) Gray iron lubricated tapered plug

6) Carbon steel sealant fitting

7) 1 year supply lubricant per valve

8) 1 lubricating gun with 15,000 psi gauge and 12 inch connection hose per 10 valves

9) 1 wrench operator per 10 valves

10) Threaded end connection

11) SCHEDULE VALVE NO. 2001

3. 2 1/2 inch to 4 inch, MSS SP 25, MSS SP-78

a. 200 psi cold working pressure (CWP)

1) ASTM A 126 gray iron body

2) Regular pattern

3) Screwed gland

4) Buna-N gland and stem seals

5) Gray iron lubricated tapered plug

6) Carbon steel sealant fitting

7) 1 year supply lubricant per valve

8) 1 lubricating gun with 15,000 psi gauge and 12 inch connection hose per 10 valves

9) 1 wrench operator per 10 valves

10) ANSI 125 flanged ends

11) SCHEDULE VALVE NO. 2011

G. IRON BUTTERFLY VALVES

1. Manufacturers - Iron butterfly valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

   a. Keystone division of Tyco Flow Control

   b. Bray Valve & Controls

   c. ABZ Valves & Controls

2. 200 psi cold working pressure (CWP), 2 inch to 24 inch

   a. ASTM A126 cast iron body

   b. ANSI 125/150 pattern, fully lugged, and tapped body style

   c. Stainless steel stem

   d. Resilient EPDM seat

   e. Bronze stem bushing

   f. Stainless steel disc screws or taper pins

H. SPRING LOADED LIFT DISC CHECK VALVES

1. Manufacturers - Spring loaded lift disc check valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Mueller Steam Specialty Co.

b. Milwaukee Valve Co.

c. Titan Flow Control, Inc.

2. 2 inch and smaller

a. 200 psi cold working pressure (CWP) up to 150ºF

1) Cast iron body and cap

2) Screwed cap

3) EPDM seal

4) Stainless steel stem

5) Stainless steel spring

6) Brass disc

7) Threaded ends

I. CALIBRATED BALANCING VALVES

1. Manufacturers - Calibrated balancing valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. ITT Bell & Gosett

b. Macon, Tunstall Corp.

c. TA Hydronics

2. 2 inch and smaller

a. 200 psi cold working pressure (CWP) up to 250ºF

1) Bronze body, straight through ball valve design

2) Brass ball

3) Carbon filled TFE seat rings

4) Read out ports with internal EPT insert and check valve

5) ¼ inch NPT tapped drain port

6) Memory stop feature

7) Calibrated nameplate

8) Sweat ends

3. 2½ inch to 3 inch

a. 175 psi cold working pressure (CWP) up to 250ºF

1) Cast iron body, straight through ball valve design

2) Brass ball

3) Carbon filled TFE seat rings

4) Read out ports with internal EPT insert and check valve

5) Memory stop feature

6) Calibrated nameplate

7) ANSI class 125 flanged end connections

4. 3 inch to 12 inch

a. 175 psi cold working pressure (CWP) up to 250ºF

1) Cast iron body, “Y” pattern globe valve design
2) Bronze seat
3) Replaceable bronze disc
4) EPDM seal insert
5) Stainless steel stem
6) Read out ports with internal EPT insert and check valve
7) Memory stop feature
8) Calibrated nameplate
9) ANSI class 125 flanged end connections

J. SAFETY VALVES

1. Manufacturers - Safety valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Conbraco Industries Inc.

b. Kunkle

2. Class 300 steam safety shut off valve, 1 inch to 6 inches

a. ASTM A 216 grade WCB cast carbon steel body

b. Normally closed, air to open

c. Integral stainless steel seat ring with cobalt nickel alloy hard facing

d. Replaceable diaphragm and stem seal

e. Suitable for dead end service with maximum leakage to ANSI B16.104 class IV

f. Actuator shall be bolted to valve bonnet and capable of closing valve against 250 psig line pressure drop

g. Teflon graphite packing

h. Cage retained internal valve parts

i. Valve and control device shall be supplied by the same manufacturer

j. ANSI class 300 flanged end connections

K. AUTOMATIC FLOW CONTROL VALVES

1. Manufacturers - Automatic flow control valves - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Griswold Controls

b. Belime Control Valves

c. TA Hydronics

2. ½ inch to 2 inch

a. 600 psi cold working pressure (CWP)

1) ASTM B283 forged brass body

2) 304 stainless steel cartridge

3) 17-7 PH stainless steel spring

4) ¼ NPT taps with pressure/temperature test valves

5) FNPT threaded ends

3. 2½ inch to 3 inch

a. 362 psi cold working pressure (CWP) up to 275ºF

1) ASTM A536-80 ductile iron body

2) 304 stainless steel cartridge

3) 17-7 PH stainless steel spring

4) ¼ NPT taps with pressure/temperature test valves

5) Pressure/temperature extensions

6) ANSI class 150 wafer type construction

7) SCHEDULE VALVE NO. 2811

L. SOLENOID VALVES

1. Solenoid valves

a. ASCO

2. 2 inch and smaller, 125 psi cold working pressure (CWP)

a. Brass body

b. NBR disc

c. PTFE seals

d. Stainless steel trim

e. Disc closing speed snubber

f. 24 VDC – schedule valve no. 2901

g. 120 VAC – schedule valve no. 2902

h. Threaded end connections

2.3 ELECTRIC MOTOR ACTUATORS

1. Manufacturers - Electric valve actuators - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Limitorque Corporation

b. Rotork Controls, Inc.

c. Belimo Air Controls, Inc.

d. EIM Company, Inc.

B. Motor valve operators.

C. Provide as follows:

1. Mount operators on side or top of valve at factory or at site under manufacturer's supervision. Provide gear operated single or double reduction. For 90 deg (1/4 turn) application, adjustable mechanical stops shall prevent travel of more than 90 deg

2. Grease or oil lubricated.

3. 120 Volt, 1 phase, 60 hertz

4. Control circuit: 24 volt, transformer as required.

5. Control circuit: 120 volt, transformer as required.

6. Assembly:

    a. Motor shall be high speed, high torque, totally enclosed non-ventilated, Class B or F insulation and operational at up to 10 percent above or below nominal voltage. Motor shall be prelubricated, anti-friction bearing type with thermal overload protection.

    b. Limit switches shall be integral to the unit. Gearing shall be bronze or stainless steel. Steel switches shall be fully adjustable and shall trip anywhere between full open and full close, as required. Switches shall be heavy duty, open contact type with rotary wiping action. Provide minimum spare contacts 2 normally open, 2 normally closed.

    c. Torque switch shall have torque protection either direction, fully adjustable and shall shut off actuator motor when a predetermined amount of torque is reached.

    d. Stem nut shall be high tensile bronze or material compatible to the valve stem and shall be constructed for easy removal without disassembling gear case.

    e. Handwheel for manual operation: Handwheel shall declutch automatically when motor is energized. Rimpull shall not exceed a maximum of 80 lb. Handwheel shall be similar to Limitorque SMB and SMC.

7. For open/closed operation: All valves shall have integral control package including control transformer with fused secondary, motor reversing contactor (mechanically interlocked), limit switch compartment heater and terminal strip.

    a. Indicating lights shall be:

        1) Red light glows when valve closed.

        2) Green light glows when valve open.

        3) Intermediate position indication.

    b. Pushbutton station: Provide selector switch if required and momentary or maintained contacts as required.

8. For modulating service shall be controlled by analog signal 4-20 ma DC with momentary pushbuttons.

a. Controls shall be mounted inside the actuator.

b. Provide three phase power supply:

1) Solid state reversing controller.

2) Comparator circuit module.

3) Transformer.

4) 2 position selector switch (auto/manual).

5) Limit switch compartment heater.

6) Mechanical dial position indicator with 1,000 ohm potentiometer.

7) Class F insulation motor.

8) Mounted and wired.

9) Similar to Limitorque Modutronic 30.

c. Provide single phase power supply:

1) Comparator circuit module.

2) Mechanical dial position indicator with 1,000 ohm potentiometer feedback.

3) 2 position (auto/manual) selector switch.

4) Limit switch compartment heater.

5) Motor: 2100 rpm D.C. in lieu of A.C.; class F insulation; 20 percent run valve duty.

6) Mounted and wired, similar to Limitorque Modutronic 10A and 10B.

9. Closing time:

a. Gate shall be 12 inches per minute, minimum 1 minute.

b. Globe shall be 4 inches per minute, minimum 1 minute.

c. Butterfly shall be 1/4 turn per minute.

10. Provide remote open-close buttons and open-close indicating lights for installation on control board in Division 15 Section “Automatic Controls System”.

11. Final field adjustment of valve operation shall be made by manufacturer's representative.

2.4 CHAINWHEEL ACTUATORS

A. Manufacturers - Chainwheel actuators - Subject to compliance with requirements, provide products by one of the following, or approved equal:

1. Babbitt Steam Specialties Co.

2. Roto Hammer Industries Inc.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides Ductile iron, of type and size required for valve.

a. Cast iron.

b. Bronze

2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

3. Chain:

a. Hot-dip, galvanized steel

b. Brass

c. Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

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

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for valves NPS 4and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated in the pipe schedule, use the following valve types:

1. Shutoff Service except Steam: Ball, butterfly or gate valves.
2. Throttling Service except Steam: Ball, plug valves, Globe valves
3. Pump Discharge Check Valves:
   a. NPS 2 (DN 50) and smaller: Bronze swing check valves with bronze disc.
   b. NPS 2 1/2 (DN 65) and Larger: Iron swing check valves with level and weight or with spring or iron, center guided, metal seat check valves.

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

C. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

D. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

E. Install spring loaded check valves at each pump discharge and elsewhere as required to control flow direction.

F. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to discharge. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

G. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

H. Threaded connections are not to be used for glycol systems.

END OF SECTION 230523

Section 230529
Hangers And Supports For Hvac Piping And Equipment

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fastener systems.
4. Pipe stands.
5. Equipment supports.

B. Related Sections:
1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

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

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Pipe stands.
3. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.4 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.5 EQUIPMENT SUPPORTS

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

2.6 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

D. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

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

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

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

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

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

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

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

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

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

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

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

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

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

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

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

Section 230533
Heat Tracing For Hvac Piping

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes heat tracing for HVAC piping with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

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

1. Chromalux
2. Raychem
3. Watts Radiant

B. Comply with IEEE 515.1.

C. Heating Element: Pair of parallel No. 16 AWG, nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: Stainless-steel braid and polyolefin outer jacket with ultraviolet inhibitor.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 185 deg F.

H. 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.

2.2 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 230533

Section 230548
Vibration And Seismic Controls For Hvac

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Elastomeric hangers.
9. Spring hangers.
10. Snubbers.
11. Restraint channel bracings.
12. Restraint cables.
13. Seismic-restraint accessories.
14. Mechanical anchor bolts.
15. Adhesive anchor bolts.
16. Vibration isolation equipment bases.
17. Restrained isolation roof-curb rails.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.

a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic- and Wind-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 95 MPH.
2. Building Classification Category: IV.

3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: Refer to existing structural drawings.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: Refer to existing structural drawings.

    a. Component Importance Factor: 1.0 refer to contract drawings.
    b. Component Response Modification Factor: 1.5 refer to existing structural drawings.
    c. Component Amplification Factor: Refer to existing structural drawings.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second).
4. Design Spectral Response Acceleration at 1.0-Second Period.
5. Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

    a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers
    a. Ace Mounting Company
    b. Mason Industries, Inc.
    c. VMC Korfund
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Ribbed pattern.
6. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

    a. Mason Industries, Inc.
    b. VMC Korfund

2. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Ace Mounting Compnay
b. Mason Industries, Inc.
c. VMC Korfund

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

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

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with threaded mounting holes and internal leveling device.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

    a. Ace Mounting Company
    b. Mason Industries, Inc.
    c. VMC Korfund

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top plate with threaded mounting holes.
    c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

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

2.10 SNUBBERS

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

a. Ace Mounting Company

b. Mason Industries, Inc.
c. VMC Korfund

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.11 RESTRAINT CHANNEL BRACINGS

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

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.12 RESTRAINT CABLES

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

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

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

2.13 SEISMIC-RESTRAINT ACCESSORIES

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

a. Ace Mounting Company
b. Mason Industries, Inc.
c. VMC Korfund

B. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

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

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

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

2.14 MECHANICAL ANCHOR BOLTS

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

    a. Ace Mounting Company
    b. Mason Industries, Inc.
    c. VMC Korfund

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

2.15 ADHESIVE ANCHOR BOLTS

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

    a. Ace Mounting Company
    b. Mason Industries, Inc.
    c. VMC Korfund

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.16 VIBRATION ISOLATION EQUIPMENT BASES

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

    a. Ace Mounting Company
    b. Mason Industries, Inc.
    c. VMC Korfund

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.17 RESTRAINED ISOLATION ROOF-CURB RAILS

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

    a. Ace Mounting Company
    b. Mason Industries, Inc.
    c. VMC Korfund

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

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

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

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

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

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

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by OSHPD an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

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

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

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

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

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

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

END OF SECTION 230548

Section 230593
Testing, Adjusting, And Balancing For Hvac

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

    a. Constant-volume air systems.
    b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems.
    c. Primary-secondary hydronic systems.

3. Testing, Adjusting, and Balancing Equipment:

    a. Heat exchangers.
    b. Motors.
    c. Chillers.
    d. Condensing units.
    e. Boilers.
    f. Heat-transfer coils.

4. Testing, adjusting, and balancing existing systems and equipment.
5. Sound tests.
6. Vibration tests.
7. Duct leakage tests.
8. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

A. Sustainable Design Submittals:

1. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 60 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 90 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.

2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. TAB Specialists Qualifications: Certified by NEBB or TABB.

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

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.8 FIELD CONDITIONS

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

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

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

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

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

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

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

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

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

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

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.

3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch pound units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses, close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

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

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure

for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
    g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
    b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
    d. Mark final settings.
    e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
    f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gage heights.

d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

   a. Measure total water flow.

      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed.
      3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

   b. Measure pump TDH as follows:

      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      3) Convert pressure to head and correct for differences in gage heights.
      4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
      5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

   c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

   a. Measure differential pressure and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

    a. Measure total water flow.

        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

    b. Measure pump TDH as follows:

        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gage heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

    c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.

b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure, and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gage heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.11 PROCEDURES FOR HEAT EXCHANGERS

A. Adjust water flow to within specified tolerances.

B. Measure inlet and outlet water temperatures.

C. Measure inlet steam pressure.

D. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.13 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator[and condenser] to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.14 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.15 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.

2. Measure and record water flow.
3. Record relief valve pressure setting.

3.16 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.17 VIBRATION TESTS

A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 10.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.18 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.19 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.20 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.21 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: [Plus or minus 10 percent] <Insert value>.
2. Air Outlets and Inlets: [Plus or minus 10 percent] <Insert value>.
3. Heating-Water Flow Rate: [Plus or minus 10 percent] <Insert value>.
4. Cooling-Water Flow Rate: [Plus or minus 10 percent] <Insert value>.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.22 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Filter static-pressure differential in inches wg.
    f. Preheat-coil static-pressure differential in inches wg.
    g. Cooling-coil static-pressure differential in inches wg.
    h. Heating-coil static-pressure differential in inches wg.
    i. Outdoor airflow in cfm.
    j. Return airflow in cfm.
    k. Outdoor-air damper position.
    l. Return-air damper position.
    m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

    a. System identification.

b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.

e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

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

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.

b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.

g. Space temperature in deg F.

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

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.

j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

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

3.23 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.

B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, Owner may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.24 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

Section 230713
Duct Insulation

RAT1 c - GENETAL

c.c TELA1EMMDOCUEN1S

A. Mrawings and general provisions of tYe Oontraht.

c.2 SCUUAT:

A. Sehtion inhludes insulating tYe following duht servihes4

c. Pndoor6honhealed supply and outdoor air.
2. Pndoor6e7posed supply and outdoor air.
3. Pndoor6honhealed return lohated in unhonditioned spahe.
8. Pndoor6honhealed e7Yaust between isolation damper and penetration of building e7terior.

B. Telated Sehtions4
c. Sehtion 2305c9 qF I AO Riping Pnsulation.q

c.3 AO1PDN SCBUP11ALS

A. Rroduht Mata4 , or eahY type of produht indihated. Pnhlude tYermal honduhtivity6 water-vapor permeanhe tYihxness6 and jahxets \botY fahtory- and field-applied if anyW

B. SYop Mrawings4 Pnhlude plans6elevations6sehtions6details6and attahYments to otYer worx.

c. Metail applihation of protehtive sYields6saddles6and inserts at Yangers for eahY type of insulation and Yanger.
2. Metail insulation applihation at elbows6fittings6dampers6spehialties and flanges for eahY type of insulation.
3. Metail applihation of field-applied jahxets.
8. Metail applihation at linxages of hontrol devihes.

c.8 PN, DTUA1PDNAL SCBUP11ALS

A. Qualifihation Mata4 , or "ualified Pnstaller.

B. Uaterial 1est Teports4 , rom a "ualified testing agenhy ahheptable to autYorities Yaving jurisdihtion indihating6 interpreting6 and hertifying test results for homplianhe of insulation materials6 sealers6 attahYments6 hements6 and jahxets6witY re"uirements indihated. Pnhlude dates of tests and test metYods employed.

O. , ield "uality-hontrol reports.

c.X QCALP1: ASSCTANOE

A. Pnstaller Qualifihations4 Sxilled mehYanihs wYo Yave suhhessfully hompleted an apprentihesYip program or anotYer hraft training program hertified by tYe Mepartment of Labor6Bureau of ApprentihesYip and 1raining.

B. Surfahe-Burning OYarahteristihs4 , or insulation and related materials6 as determined by testing identihal produhts ahhording to AS1U E z86by a testing agenhy ahheptable to autYorities Yaving jurisdihtion. , ahtory label insulation and jahxet materials and adYesive6mastih6tapes6and hement material hontainers6witY appropriate marxings of applihable testing agenhy.

c. Pnsulation Pnstalled Pndoors4 , lame-spread inde7 of 2X or less6and smoxe-developed inde7 of X0 or less.
2. Pnsulation Pnstalled Dutdoors4 , lame-spread inde7 of 5X or less6and smoxe-developed inde7 of cX0 or less.

c.k MELP ET: 6S1DTAGE6ANM FANMLPNG

A. Rahxaging4 Pnsulation material hontainers sYall be marxed by manufahturer witY appropriate AS1U standard designation6type and grade6and ma7imum use temperature.

c.5 ODDTMPNA1PDN

A. Ooordinate siHes and lohations of supports6Yangers6and insulation sYields.

B. Ooordinate hlearanhe re" uirements witY duht Pnstaller for duht insulation applihation. Before preparing duhtworx SYop Mrawings6 establisY and maintain hlearanhe re" uirements for installation of insulation and field-applied jahxets and finisYes and for spahe re" uired for maintenanhe.

O. Ooordinate installation and testing of Yeat trahing.

c.z SOFEMCLPNG

A. ShYedule insulation applihation after pressure testing systems and6 wYere re" uired6 after installing and testing Yeat trahing. Pnsulation applihation may begin on segments tYat Yave satisfahtory test results.

B. Oomplete installation and honhealment of plastih materials as rapidly as possible in eahY area of honstruhtion.

RAT1 2 - RTDMCO1S

2.c PNSCLA1PDN UA1ETPALS

A. Oomply witY re" uirements on Oontraht Mrawings for wYere insulating materials sYall be applied.

B. Rroduhts sYall not hontain asbestos6lead6merhury6or merhury hompounds.

O. Rroduhts tYat home in hontaht witY stainless steel sYall Yave a leahYable hYloride hontent of less tYan X0 ppm wYen tested ahhording to AS1U O z5c.

M. Pnsulation materials for use on austenitih stainless steel sYall be " ualified as ahheptable ahhording to AS1U O 59X.

E. Uineral-, iber Blanxet Pnsulation4 Uineral or glass fibers bonded witY a tYermosetting resin. Oomply witY AS1U O XX36 1ype PP and AS1U O c2906 1ype PPP witY fahtory-applied , SK jahxet. , ahtory-applied jahxet re" uirements are spehified in q ahtory-Applied JahxetsqArtihle.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. Oertain1eed Oorp./ Soft1ouhY Muht ; rap.
b. JoYns Uanville/ Uihrolite.
h. Knauf Pnsulation/ , riendly , eel Muht ; rap.
d. Uanson Pnsulation Pnh./ Alley ; rap.
e. Owens Oorning/ SO, 1T All-Servihe Muht ; rap.

B. Uineral-, iber Board Pnsulation4 Uineral or glass fibers bonded witY a tYermosetting resin. Oomply witY AS1U O kc26 1ype PA or 1ype PB. , or duht and plenum applihations6provide insulation witY fahtory-applied , SK jahxet. , ahtory-applied jahxet re" uirements are spehified in q ahtory-Applied JahxetsqArtihle.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. Oertain1eed Oorp./ Oommerhial Board.
b. , ibre7 Pnsulations Pnh./ , BZ.
h. JoYns Uanville/ z00 Series Spin-Glas.
d. Knauf Pnsulation/ Pnsulation Board.
e. Uanson Pnsulation Pnh./ AK Board.
f. Owens Oorning/ , iberglas 500 Series.

2.2 AMFESP ES

A. Uaterials sYall be hompatible witY insulation materials6jahxets6and substrates and for bonding insulation to itself and to surfahes to be insulated unless otYerwise indihated.

B. Uineral-, iber AdYesive4 Oomply witY UPL-A-33ckO6Olass 26Grade A.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. OYilders Brand6 Spehialty Oonstruhtion Brands6 Pnh.6 a business of F. B. , uller Oompany/ OR-c25.Eagle Bridges - UaratYon Pndustries/ 22X.
b. , oster Brand6 Spehialty Oonstruhtion Brands6 Pnh.6 a business of F. B. , uller Oompany/ zX-k0&X-50.Uon-Eho Pndustries6Pnh./ 22-2X.

2. , or indoor applihations6 adYesive sYall Yave a l DO hontent of z0 g&L or less wYen halhulated ahhording to 80 O, T X96Subpart M \ERA UetYod 28W.

B. ASJ AdYesive6and , SK Jahxet AdYesive4 Oomply witY UPL-A-33ckO6Olass 26Grade A for bonding insulation jahxet lap seams and joints.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. OYilders Brand6Spehialty Oonstruhtion Brands6Phh.6a business of F. B. , uller Oompany/ OR-z2.
b. Eagle Bridges - UaratYon Phdustries/ 22X.
h. , oster Brand6Spehialty Oonstruhtion Brands6Phh.6a business of F. B. , uller Oompany/ zX-X0.Uon-Eho Phdustries6Phh./ 22-2X.

2. , or indoor applihations6adYesive sYall Yave a l DO hontent of X0 g&L or less wYen halhulated ahhording to 80 O, T X96Subpart M\ERA UetYod 28W.

2.3 SEALAN1S

A. , SK and Uetal Jahxet , lasYing Sealants4

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. OYilders Brand6Spehialty Oonstruhtion Brands6Phh.6a business of F. B. , uller Oompany/ OR-5k.Eagle Bridges - UaratYon Phdustries/ 80X.
b. , oster Brand6Spehialty Oonstruhtion Brands6Phh.6a business of F. B. , uller Oompany/ 9X-88.
h. Uon-Eho Phdustries6Phh./ 88-0X.

2. Uaterils sYall be hompatible witY insulation materials6jahxets6and substrates.
3. , ire- and water-resistant6fle7ible6elastomerih sealant.
8. Servihe 1emperature Tange4 Uinus 80 to plus 2X0 deg , .
X. Oolor4 Aluminum.
k. , or indoor applihations6sealants sYall Yave a l DO hontent of 820 g&L or less wYen halhulated ahhording to 80 O, T X96Subpart M\ERA UetYod 28W.

2.8 , AO1DT: -ARRLPEMJAOKE1S

A. Phsulation system shYedules indihate fahtory-applied jahxets on various applihations. ; Yen fahtory-applied jahxets are indihated6homply witY tYe following4

c. ASJ4 ; Yite6xraft-paper6fiberglass-reinforhed shrim witY aluminum-foil bahxing/ homplying witY AS1U O cc3k6 1ype P.
2. ASJ-SSL4 ASJ witY self-sealing6 pressure-sensitive6 ahrylih-based adYesive hovered by a removable protehtive strip/ homplying witY AS1U O cc3k61ype P.
3. , SK Jahxet4 Aluminum-foil6 fiberglass-reinforhed shrim witY xraft-paper bahxing/ homplying witY AS1U O cc3k61ype PP.
8. , SR Jahxet4 Aluminum-foil6 fiberglass-reinforhed shrim witY polyetYylene bahxing/ homplying witY AS1U O cc3k61ype PP.
X. l inyl Jahxet4 ; Yite vinyl witY a permeanhe of c.3 perms wYen tested ahhording to AS1U E 9k&E 9kU6 Rrohedure A6and homplying witY N, RA 90A and N, RA 90B.

2.X 1ARES

A. , SK 1ape4 , oil-fahe6 vapor-retarder tape mathYing fahtory-applied jahxet witY ahrylih adYesive/ homplying witY AS1U O cc3k.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. ABR&Rdeal 1ape Mivision/ 89c A; , , SK.
b. Avery Mennison Oorporation6Spehialty 1apes Mivision/ , asson 0z25.
h. Oompah Oorporation/ cc0 and ccc.
d. I enture 1ape/ cX2X O; N16cX2z O; 6and cX2z O; &SQ.

2. ; idtY4 3 inhYes.
3. 1Yihxness4 k.X mils.
8. AdYesion4 90 ounhes forhe&nhY in widtY.
X. Elongation4 2 perhent.
k. 1ensile StrengtY4 80 lbf&nhY in widtY.
5. , SK 1ape Misxs and S" uares4 Rrehut disxs or s" uares of , SK tape.

B. Aluminum-, oil 1ape4 I apor-retarder tape witY ahrylih adYesive.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. ABR&Rdeal 1ape Mivision/ 8zz A; , .
b. Avery Mennison Oorporation6Spehialty 1apes Mivision/ , asson 0z00.
h. Oompah Oorporation/ c20.
d. I enture 1ape/ 3X20 O; .

2. ; idtY4 2 inhYes.
3. 1Yihxness4 3.5 mils.
8. AdYesion4 c00 ounhes forhe&nhY in widtY.
X. Elongation4 X perhent.
k. 1ensile StrengtY4 38 lbf&nhY in widtY.

2.k SEOCTEUEN1S

A. Bands4

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. P1; Pnsulation Systems/ Gerrard Strapping and Seals.
b. TRT Rroduhts6Pnh./ Pnsul-Uate Strapping6Seals6and Springs.

2. Stainless Steel4 AS1U A ck5 or AS1U A 280&A 280U6 1ype 308/ 0.0cX inhY tYihx6 c&2 inhY wide witY wing seal or hlosed seal.
3. Aluminum4 AS1U B 2096Alloy 30036300X63c0X6or X00X/ 1emper F-c860.020 inhY tYihx6 c&2 inhY wide witY wing seal or hlosed seal.
8. Springs4 1win spring set honstruhted of stainless steel witY ends flat and slotted to ahhept metal bands. Spring siHe determined by manufahturer for applihation.

B. Insulation Rins and Fangers:

c. Oapahitor-MishYarge-; eld Rins: Oopper- or Hnh-hoated steel pin, fully annealed for hapahitor-dishYarge welding, 0.c3X-inhY- diameter sYanx, lengtY to suit deptY of insulation indihated.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements, provide produhts by one of tYe following, or approved e" ual:

cW AGU Industries, Inh./ O; R-c.
2W GEUOD/ OM.
3W Uidwest , asteners, Inh./ OM.
8W Nelson Stud ; elding/ 1RA61RO, and 1RS.

2. Oupped-Fead, Oapahitor-MishYarge-; eld Rins: Oopper- or Hnh-hoated steel pin, fully annealed for hapahitor-dishYarge welding, 0.c3X inhY- diameter sYanx, lengtY to suit deptY of insulation indihated witY integral c-c&2-inhY galvaniHed harbon-steel wasYer.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements, provide produhts by one of tYe following, or approved e" ual:

cW AGU Industries, Inh./ OFR-c.
2W GEUOD/ Oupped Fead ; eld Rin.
3W Uidwest , asteners, Inh./ Oupped Fead.
8W Nelson Stud ; elding/ OFR.

2. Uetal, AdYesively AttahYed, Rerforated-Base Insulation Fangers: Baseplate welded to projehting spindle tYat is hapable of Yolding insulation of tYihxness indihated, sehurely in position indihated wYen self-lohxing wasYer is in plahe. Oomply witY tYe following re" uirements:

A. Uanufahturers - Subjeht to homplianhe witY re" uirements, provide produhts by one of tYe following, or approved e" ual:

cW AGU Industries, Inh./ 1ahtoo Rerforated Base Insul-Fangers.
2W GEUOD/ Rerforated Base.
3W Uidwest , asteners, Inh./ Spindle.

b. Baseplate: Rerforated, galvaniHed harbon-steel sYeet, 0.030 inhY tYihx by 2 inhYes s" uare.
h. Spindle: Oopper- or Hnh-hoated, low-harbon steel Aluminum Stainless steel, fully annealed, 0.c0k-inhY-diameter sYanx, lengtY to suit deptY of insulation indihated.
d. AdYesive: Tehommended by Yanger manufahturer. Rroduht witY demonstrated hapability to bond insulation Yanger sehurely to substrates indihated witYout damaging insulation, Yangers, and substrates.

2. Nonmetal, AdYesively AttahYed, Rerforated-Base Insulation Fangers: Baseplate fastened to projehting spindle tYat is hapable of Yolding insulation of tYihxness indihated, sehurely in position indihated wYen self-lohxing wasYer is in plahe. Oomply witY tYe following re" uirements:

A. Uanufahturers - Subjeht to homplianhe witY re" uirements, provide produhts by one of tYe following, or approved e" ual:

cW GEUOD/ Nylon Fangers.
2W Uidwest , asteners6Pnh./ Nylon Pnsulation Fangers.

b. Baseplate4 Rerforated6nylon sYeet60.030 inhY tYihx by c-c&2 inhYes in diameter.
h. Spindle4 Nylon6 0.c0k-inhY-diameter sYanx6 lengtY to suit deptY of insulation indihated6 up to 2-c&2 inhYes.
d. AdYesive4 Tehommended by Yanger manufahturer. Rroduht witY demonstrated hapability to bond insulation Yanger sehurely to substrates indihated witYout damaging insulation6 Yangers6 and substrates.

2. Self-Stihxing-Base Pnsulation Fangers4 Baseplate welded to projehting spindle tYat is hapable of Yolding insulation6 of tYihxness indihated6 sehurely in position indihated wYen self-lohxing wasYer is in plahe. Oomply witY tYe following re" uirements4

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6 provide produhts by one of tYe following6 or approved e" ual4

cW AGU Pndustries6Pnh./ 1ahtoo Self-AdYering Pnsul-Fangers.
2W GEUOD/ Reel) Rress.
3W Uidwest , asteners6Pnh./ Self Stihx.

b. Baseplate4 GalvaniHed harbon-steel sYeet60.030 inhY tYihx by 2 inhYes s" uare.
h. Spindle4 Oopper- or Hnh-hoated6 low-harbon steel Aluminum Stainless steel6 fully annealed60.c0k-inhY-diameter sYanx6 lengtY to suit deptY of insulation indihated.
d. AdYesive-bahxed base witY a peel-off protehtive hover.

2. Pnsulation-Tetaining ; asYers4 Self-lohxing wasYers formed from 0.0ck-inhY-tYihx6 galvaniHed-steel aluminum stainless-steel sYeet6 witY beveled edge siHed as re" uired to Yold insulation sehurely in plahe but not less tYan c-c&2 inhYes in diameter.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6 provide produhts by one of tYe following6 or approved e" ual4

cW AGU Pndustries6Pnh./ TO-cX0.
2W GEUOD/ T-cX0.
3W Uidwest , asteners6Pnh./ ; A-cX0.
8W Nelson Stud ; elding/ Speed Olips.

b. Rroteht ends witY happed self-lohxing wasYers inhorporating a spring steel insert to ensure permanent retention of hap in e7posed lohations.

2. Nonmetal Pnsulation-Tetaining ; asYers4 Self-lohxing wasYers formed from 0.0ck-inhY-tYihx nylon sYeet6 witY beveled edge siHed as re" uired to Yold insulation sehurely in plahe but not less tYan c-c&2 inhYes in diameter.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6 provide produhts by one of tYe following6 or approved e" ual4

cW GEUOD.
2W Uidwest , asteners6Pnh.

B. Staples4 Dutward-hlinhYing insulation staples6 nominal 3&8-inhY-wide6 stainless steel or Uonel.

O. ; ire4 0.0z0-inhY nihxel-hopper alloy 0.0k2-inhY soft-annealed6 stainless steel 0.0k2-inhY soft-annealed6 galvaniHed steel.

A. Uanufahturers - Subjeht to homplianhe witY re" uirements6provide produhts by one of tYe following6or approved e" ual4

a. O) , ; ire.

2.5 ODTNET ANGLES

A. RI O Oorner Angles4 30 mils tYihx6minimum c by c inhY6RI O ahhording to AS1U M c5z86Olass ck3X8-O. ; Yite or holor-hoded to mathY adjahent surfahe.

B. Aluminum Oorner Angles4 0.080 inhY tYihx6minimum c by c inhY6aluminum ahhording to AS1U B 2096Alloy 30036 300X63c0X6or X00X/ 1emper F-c8.

O. Stainless-Steel Oorner Angles4 0.028 inhY tYihx6minimum c by c inhY6stainless steel ahhording to AS1U A ck5 or AS1U A 2808A 280U61ype 308.

RAT1 3 - EZEOC1PDN

3.c EZAUPNA1PDN

A. E7amine substrates and honditions for homplianhe witY re" uirements for installation toleranhes and otYer honditions affehting performanhe of insulation applihation.

c. I erify tYat systems to be insulated Yave been tested and are free of defehts.
2. I erify tYat surfahes to be insulated are hlean and dry.

B. Rroheed witY installation only after unsatisfahtory honditions Yave been horrehted.

3.2 RTERATA1PDN

A. Surfahe Rreparation4 Olean and dry surfahes to reheive insulation. Temove materials tYat will adversely affeht insulation applihation.

3.3 GENETAL PNS1ALLA1PDN TEQCPTEUEN1S

A. Pnstall insulation materials6ahhessories6and finisYes witY smootY6straigYt6and even surfahes/ free of voids tYrougYout tYe lengtY of duhts and fittings.

B. Pnstall insulation materials6vapor barriers or retarders6jahxets6and tYihxnesses re" uired for eahY item of duht system as spehified in insulation system shYedules.

O. Pnstall ahhessories hompatible witY insulation materials and suitable for tYe servihe. Pnstall ahhessories tYat do not horrode6soften6or otYerwise attahx insulation or jahxet in eitYer wet or dry state.

M. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. If vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tight butt join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. If vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.8 RENE1TA1PDNS

A. Pnsulation Pnstallation at Toof Renetrations4 Pnstall insulation hontinuously tYrougY roof penetrations.

c. Seal penetrations witY flasYing sealant.
2. , or applihations re" uiring only indoor insulation6 terminate insulation above roof surfahe and seal witY joint sealant. , or applihations re" uiring indoor and outdoor insulation6 install insulation for outdoor applihations tigYtly joined to indoor insulation ends. Seal joint witY joint sealant.
3. E7tend jahxet of outdoor insulation outside roof flasYing at least 2 inhYes below top of roof flasYing.
8. Seal jahxet to roof flasYing witY flasYing sealant.

B. Pnsulation Pnstallation at Aboveground E7terior ; all Renetrations4 Pnstall insulation hontinuously tYrougY wall penetrations.

c. Seal penetrations witY flasYing sealant.
2. , or applihations re" uiring only indoor insulation6 terminate insulation inside wall surfahe and seal witY joint sealant. , or applihations re" uiring indoor and outdoor insulation6 install insulation for outdoor applihations tigYtly joined to indoor insulation ends. Seal joint witY joint sealant.
3. E7tend jahxet of outdoor insulation outside wall flasYing and overlap wall flasYing at least 2 inhYes.
8. Seal jahxet to wall flasYing witY flasYing sealant.

O. Pnsulation Pnstallation at Pnterior ; all and Rartition Renetrations VlYat Are Not , ire TatedW Pnstall insulation hontinuously tYrougY walls and partitions.

M. Pnsulation Pnstallation at , ire-Tated ; all and Rartition Renetrations4 1erminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. E7ternally insulate damper sleeves to mathY adjahent insulation and overlap duht insulation at least 2 inhYes.

c. Oomply witY re" uirements in Sehtion 05z8c3 oRenetration , irestopping q, irestopping and fire-resistive joint sealers.

E. Pnsulation Pnstallation at , loor Renetrations4

c. Muht4 , or penetrations tYrougY fire-rated assemblies6 terminate insulation at fire damper sleeves and e7ternally insulate damper sleeve beyond floor to mathY adjahent duht insulation. Dverlap damper sleeve and duht insulation at least 2 inhYes.
2. Seal penetrations tYrougY fire-rated assemblies. Oomply witY re" uirements in Sehtion 05z8c3 oRenetration , irestopping.q

3.X PNS1ALLA1PDN D, , LEZPBLE ELAS1DUE1PO PNSCLA1PDN

A. Seal longitudinal seams and end joints witY manufahturer's rehommended adYesive to eliminate openings in insulation tYat allow passage of air to surfahe being insulated.

3.k PNS1ALLA1PDN D, UPNETAL-, PBET PNSCLA1PDN

A. Blanxet Pnsulation Pnstallation on Muhts and Rlenums4 Sehure witY adYesive and insulation pins.

c. Apply adYesives ahhording to manufahturer's rehommended hoverage rates per unit area6 for X0 perhent hoverage of duht and plenum surfahes.
2. Apply adYesive to entire hirhumferenhe of duhts and to all surfahes of fittings and transitions.
3. Pnstall eitYer hapahitor-dishYarge-weld pins and speed wasYers or hupped-Yead6 hapahitor-dishYarge-weld pins on sides and bottom of YoriHbntal duhts and sides of vertihal duhts as follows4

a. Dn duht sides witY dimensions cz inhYes and smaller6 plahe pins along longitudinal henterline of duht. Spahe 3 inhYes ma7imum from insulation end joints6 and ck inhYes o.h.
b. Dn duht sides witY dimensions larger tYan cz inhYes6 plahe pins ck inhYes o.h. eahY way6 and 3 inhYes ma7imum from insulation joints. Pnstall additional pins to Yold insulation tigYtly against surfahe at hross brahing.
h. Rins may be omitted from top surfahe of YoriHbntal6 rehtangular duhts and plenums.
d. Mo not overhompress insulation during installation.
e. Pnpale insulation over pins and attahY speed wasYers.
f. Out e7hess portion of pins e7tending beyond speed wasYers or bend parallel witY insulation surfahe. Oover e7posed pins and wasYers witY tape mathYing insulation fahing.

8. , or duhts and plenums witY surfahe temperatures below ambient6 install a hontinuous unbroxen vapor barrier. Oreate a fahing lap for longitudinal seams and end joints witY insulation by removing 2 inhYes from one edge and one end of insulation segment. Sehure laps to adjahent insulation sehtion witY c&2-inhY outward-hlinhYing staples6 c inhY o.h. Pnstall vapor barrier honsisting of fahtory- or field-applied jahxet6 adYesive6 vapor-barrier mastih6 and sealant at joints6 seams6 and protrusions.

a. Tepair punhtures6 tears6 and penetrations witY tape or mastih to maintain vapor-barrier seal.
b. Pnstall vapor stops for duhtworx and plenums operating below X0 deg , at cz-foot intervals. I apor stops sYall honsist of vapor-barrier mastih applied in a (-sYaped pattern over insulation fahe6 along butt end of insulation6 and over tYe surfahe. Oover insulation fahe and surfahe to be insulated a widtY e" ual to two times tYe insulation tYihxness6 but not less tYan 3 inhYes.

X. Dverlap unfahed blanxets a minimum of 2 inhYes on longitudinal seams and end joints. At end joints6 sehure witY steel bands spahed a ma7imum of cz inhYes o.h.
k. Pnstall insulation on rehtangular duht elbows and transitions witY a full insulation sehtion for eahY surfahe. Pnstall insulation on round and flat-oval duht elbows witY individually mitered gores hut to fit tYe elbow.
5. Pnsulate duht stiffeners6 Yangers6 and flanges tYat protrude beyond insulation surfahe witY k-inhY-wide strips of same material used to insulate duht. Sehure on alternating sides of stiffener6 Yanger6 and flange witY pins spahed k inhYes o.h.

B. Board Pnsulation Pnstallation on Muhts and Rlenums4 Sehure witY adYesive and insulation pins.

c. Apply adYesives ahhording to manufahturer's rehommended hoverage rates per unit area6 for X0 perhent hoverage of duht and plenum surfahes.

2. Apply adYesive to entire hirhumferenhe of duhts and to all surfahes of fittings and transitions.

3. Pnstall eitYer hapahitor-dishYarge-weld pins and speed wasYers or hupped-Yead6 hapahitor-dishYarge-weld pins on sides and bottom of YoriHbntal duhts and sides of vertihal duhts as follows4

   a. Dn duht sides witY dimensions cz inhYes and smaller6 plahe pins along longitudinal henterline of duht. Spahe 3 inhYes ma7imum from insulation end joints6 and ck inhYes o.h.

   b. Dn duht sides witY dimensions larger tYan cz inhYes6 spahe pins ck inhYes o.h. eahY way6 and 3 inhYes ma7imum from insulation joints. Pnstall additional pins to Yold insulation tigYtly against surfahe at hross brahing.

   h. Rins may be omitted from top surfahe of YoriHbntal6 rehtangular duhts and plenums.

   d. Mo not overhompress insulation during installation.

   e. Out e7hess portion of pins e7tending beyond speed wasYers or bend parallel witY insulation surfahe. Oover e7posed pins and wasYers witY tape mathYing insulation fahing.

8. , or duhts and plenums witY surfahe temperatures below ambient6 install a hontinuous unbroxen vapor barrier. Oreate a fahing lap for longitudinal seams and end joints witY insulation by removing 2 inhYes from one edge and one end of insulation segment. Sehure laps to adjahent insulation sehtion witY c&2-inhY outward-hlinhYing staples6 c inhY o.h. Pnstall vapor barrier honsisting of fahtory- or field-applied jahxet6 adYesive6 vapor-barrier mastih6 and sealant at joints6 seams6 and protrusions.

   a. Tepair punhtures6 tears6 and penetrations witY tape or mastih to maintain vapor-barrier seal.

   b. Pnstall vapor stops for duhtworx and plenums operating below X0 deg , at cz-foot intervals. I apor stops sYall honsist of vapor-barrier mastih applied in a (-sYaped pattern over insulation fahe6 along butt end of insulation6 and over tYe surfahe. Oover insulation fahe and surfahe to be insulated a widtY e" ual to two times tYe insulation tYihxness6 but not less tYan 3 inhYes.

X. Pnstall insulation on rehtangular duht elbows and transitions witY a full insulation sehtion for eahY surfahe. Groove and shore insulation to fit as hlosely as possible to outside and inside radius of elbows. Pnstall insulation on round and flat-oval duht elbows witY individually mitered gores hut to fit tYe elbow.

k. Pnsulate duht stiffeners6 Yangers6 and flanges tYat protrude beyond insulation surfahe witY k-inhY-wide strips of same material used to insulate duht. Sehure on alternating sides of stiffener6 Yanger6 and flange witY pins spahed k inhYes o.h.

3.5 , PELMQCALP1: ODN1TDL

A. 1esting Agenhy4 Engage a " ualified testing agenhy to perform tests and inspehtions.

B. Rerform tests and inspehtions.

O. 1ests and Pnspehtions4

c. Pnspeht duhtworx6 randomly selehted by ArhYiteht6 by removing field-applied jahxet and insulation in layers in reverse order of tYeir installation. E7tent of inspehtion sYall be limited to one lohation\sWfor eahY duht system defined in tYe qMuht Pnsulation ShYedule6 GeneralqArtihle.

M. All insulation applihations will be honsidered defehtive ; orx if sample inspehtion reveals nonhomplianhe witY re" uirements.

3.z MCO1 PNSCLA1PDN SOF EMCLE6 GENETAL

A. Tefer to Oontraht Mrawings.

ENMD, SEO1PDN 2305c3

Section 230719
Hvac Piping Insulation

TA- Gc EN. D. - AL

c0 - . LAG. C CURwf . DGS

AO CraYings and general provisions o: t4e Rontra6tO

c02 Swf f A- 7

AO Se6tion in6ludes insulating t4e :olloYing h PAR piping systems8
cO h eating 4otEYater piping9indoorsO
2O R4illed Yater piping indoorsO
3O LoY pressure steam and 6ondensate piping9indoorsO
qO h ig4 pressure steam and 6ondensate piping9indoorsO

BO - elated Se6tions8

cO Se6tion 2305c3 FCu6t 1nsulationGF

RO S4op CraYings8 1n6lude plans9elevations9se6tions9details9and atta64ments to ot4er YorlO

cO Cetail appli6ation o: prote6tive s4ields9saddles9and inserts at 4angers :or ea64 type o: insulation and 4angerO
2O Cetail insulation appli6ation at pipe e, pansion xoints :or ea64 type o: insulationO
3O Cetail insulation appli6ation at elboYs9:ittings9:langes9valves9and spe6ialties :or ea64 type o: insulationO
qO Cetail removable insulation at piping spe6ialtiesO

c03 1Dj U- f AG1UDAL SwBf 1GGALS

AO Vuali:i6ation Cata8 j or Wuali:ied 1nstallerO

BO f aterial Gest - eports8 j rom a Wuali:ied testing agen6y a66eptable to aut4orities 4aving xurisdi6tion indi6ating9 interpreting9and 6erti:ying test results :or 6omplian6e o: insulation materials9sealers9atta64ments96ements9and xa6l ets9Yit4 reWuirements indi6atedO 1n6lude dates o: tests and test met4ods employedO

RO j ield WualityE6ontrol reportsO

c0q VwAL1G7 ASSw- ADR.

AO 1nstaller Vuali:i6ations8 SI illed me64ani6s Y4o 4ave su66ess:ully 6ompleted an apprenti6es4ip program or anot4er 6ra:t training program 6erti:ied by t4e Cepartment o: Labor9Bureau o: Apprenti6es4ip and GrainingO

BO Sur:a6eEBurning R4ara6teristi6s8 j or insulation and related materials9 as determined by testing identi6al produ6ts a66ording to ASGf . Qq9 by a testing and inspe6ting agen6y a66eptable to aut4orities 4aving xurisdi6tionO j a6tory label insulation and xa6l et materials and ad4esive9 masti69 tapes9 and 6ement material 6ontainers9Yit4 appropriate marl ings o: appli6able testing agen6yO

cO 1nsulation 1nstalled 1ndoors8 j lameEspread inde, o: 2" or less9and smol eEdeveloped inde, o: " 0 or lessO
2O 1nsulation 1nstalled Uutdoors8 j lameEspread inde, o: 5" or less9and smol eEdeveloped inde, o: c" 0 or lessO

c0 C. L1P. - 79SGU- AN. 9ADC h ADCL1DN

AO Ta6l aging8 1nsulation material 6ontainers s4all be marl ed by manu:a6turer Yit4 appropriate ASGf standard designation9type and grade9and ma, imum use temperatureO

c0X RUU- C1DAG1UD

AO Roordinate 6learan6e reWuirements Yit4 piping 1nstaller :or piping insulation appli6ationO Be:ore preparing piping S4op CraYings9 establis4 and maintain 6learan6e reWuirements :or installation o: insulation and :ieldEapplied xa6l ets and :inis4es and :or spa6e reWuired :or maintenan6eO

BO Roordinate installation and testing o: 4eat tra6ingO

c05 SRh . CwL1DN

AO S64edule insulation appli6ation a:ter pressure testing systems and9 Y4ere reWuired9 a:ter installing and testing 4eat tra6ingO 1nsulation appli6ation may begin on segments t4at 4ave satis:a6tory test resultsO

BO Romplete installation and 6on6ealment o: plasti6 materials as rapidly as possible in ea64 area o: 6onstru6tionO

TA- G2 ET- UCwRGS

20 1DSwLAG1UD f AG. - 1ALS

AO Romply Yit4 reWuirements on Rontra6t CraYingsO

BO Trodu6ts s4all not 6ontain asbestos9lead9mer6ury9or mer6ury 6ompoundsO

RO Trodu6ts t4at 6ome in 6onta6t Yit4 stainless steel s4all 4ave a lea64able 64loride 6ontent o: less t4an " 0 ppm Y4en tested a66ording to ASGf R Q5cO

CO 1nsulation materials :or use on austeniti6 stainless steel s4all be Wuali:ied as a66eptable a66ording to ASGf R 5M" O

. O Ral6ium Sili6ate8

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO 1ndustrial 1nsulation Nroup

2O Tre:ormed Tipe Se6tions8 j latE9 6urvedE9 and grooveEblo6l se6tions o: non6ombustible9 inorgani69 4ydrous 6al6ium sili6ate Yit4 a nonEasbestos :ibrous rein:or6ementORomply Yit4 ASGf R " 339Gype 1O

3O j latE9 6urvedEand grooveEblo6l se6tions o: non6ombustible9 inorgani69 4ydrous 6al6ium sili6ate Yit4 a nonEasbestos :ibrous rein:or6ementORomply Yit4 ASGf R " 339Gype 1O

qO Tre:abri6ated j itting Rovers8 Romply Yit4 ASGf R q" 0 and ASGf R " Q' :or dimensions used in pre:orming insulation to 6over valves9 elboYs9 tees9 and :langesO

j O Rellular Nlass8 1norgani69 in6ombustible9 :oamed or 6ellulated glass Yit4 annealed9 rigid9 4ermeti6ally sealed 6ellsO j a6toryEapplied xa6l et reWuirements are spe6i:ied in Fj a6toryEApplied za6l etsFArti6leO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO Tittsburg4 Rorning Rorporation

2O Blo6l 1nsulation8ASGf R " " 29Gype 1O

3O Spe6ialES4aped 1nsulation8ASGf R " " 29Gype 11O

qO Board 1nsulation8ASGf R " " 29Gype 1PO

" O Tre:ormed Tipe 1nsulation Yit4out za6l et8Romply Yit4 ASGf R " " 29Gype 19Rlass cO

XO Tre:ormed Tipe 1nsulation Yit4 j a6toryEApplied ASz8Romply Yit4 ASGf R " " 29Gype 19Rlass 2O

5O j a6tory :abri6ate s4apes a66ording to ASGf R q" 0 and ASGf R " Q' O

NO j le, ible . lastomeri6 1nsulation8RlosedEBell9 spongeEor e, pandedErubber materialsORomply Yit4 ASGf R " 3q9 Gype 1:or tubular materialsO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO Aero:le, wSA91n6O

bO Arma6ell9LLR

6O KEj le, wSA

hO f ineralEj iber BlanI et 1nsulation8 f ineral or glass :ibers bonded Yit4 a t4ermosetting resinORomply Yit4 ASGf R " " 39 Gype 11 and ASGf R c2M09 Gype 111 Yit4 :a6toryEapplied j SK xa6l etO j a6toryEapplied xa6l et reWuirements are spe6i:ied in Fj a6toryEApplied za6l etsFArti6leO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO RertainGeed Rorporation

bO zo4ns f anvilleO

6O Knau: 1nsulation
dO f anson 1nsulation 1n6O
eO UYens Rorning

1O f ineralE; iber9Tre:ormed Tipe 1nsulation8

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9provide produ6ts by one o: t4e :olloYing9or approved eWual8

aO RertainGeed Rorporation
bO zo4ns f anvilleO
6O Knau: 1nsulation
dO f anson 1nsulation 1n6O
eO UYens Rorning

2O Gype 19Q'0 deg j f aterials8 f ineral or glass :ibers bonded Yit4 a t4ermosetting resinO Romply Yit4 ASGf R "q59Gype 19Nrade A9Yit4 :a6toryEapplied ASzESSLO j a6toryEapplied xa6l et reWuirements are spe6i:ied in Fj a6toryEApplied za6l etsFArti6leO

202 1DSwLAG1DN R. f . DGS

AO f ineralE; iber 1nsulating Rement8 Romply Yit4 ASGf R cM'O

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9provide produ6ts by one o: t4e :olloYing9or approved eWual8

aO - am6o 1nsulation91n60RSuperEStil O

BO f ineralE; iber9h ydrauli6ESetting 1nsulating and j inis4ing Rement8 Romply Yit4 ASGf R qqMO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9provide produ6ts by one o: t4e :olloYing9or approved eWual8

aO - am6o 1nsulation91n60R- am6ote c200 and Vuil ERoteO

203 ACh . S1P. S

AO f ineralE; iber Ad4esive8 Romply Yit4 f 1LEAE3cXR9Rlass 29Nrade AO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9provide produ6ts by one o: t4e :olloYing9or approved eWual8

aO R4ilders Brand9Spe6ialty Ronstru6tion Brands91n609a business o: h OBOj uller Rompanyk RTE c25O
bO . agle Bridges Ef arat4on 1ndustriesk22"O
6O j oster Brand9Spe6ialty Ronstru6tion Brands91n609a business o: h OBOj uller RompanykQ'EX0HQ'E 50O
dO f onE 6o 1ndustries91n60R22E2"O

2O j or indoor appli6ations9ad4esive s4all 4ave a PUR 6ontent o: Q0 gHL or less Y4en 6al6ulated a66ording to q0 Rj - "M9Subpart C J. TA f et4od 2q/O

BO ASz Ad4esive9and j SK and TPCR za6l et Ad4esive8 Romply Yit4 f 1LEAE3cXR9Rlass 29Nrade A :or bonding insulation xa6l et lap seams and xointsO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9provide produ6ts by one o: t4e :olloYing9or approved eWual8

aO R4ilders Brand9Spe6ialty Ronstru6tion Brands91n609a business o: h OBOJ uller RompanykRTEQ2O
bO . agle Bridges Ef arat4on 1ndustriesk22" O
6O j oster Brand9Spe6ialty Ronstru6tion Brands91n609a business o: h OBOJ uller RompanykQ'E"0O
dO f onE 6o 1ndustries91n60R22E2" O

2O j or indoor appli6ations9ad4esive s4all 4ave a PUR 6ontent o: "0 gHL or less Y4en 6al6ulated a66ording to q0 Rj - "M9Subpart C J. TA f et4od 2q/O

20q j ARGU- 7EATTL1 C zARK. GS

AO 1nsulation system s64edules indi6ate :a6toryEapplied xa6l ets on various appli6ationsO ; 4en :a6toryEapplied xa6l ets are indi6ated96omply Yit4 t4e :olloYing8

cO ASz8 ; 4ite9 I ra:tEpaper9 :iberglassEein:or6ed s6rim Yit4 aluminumEoil ba6l ingk 6omplying Yit4 ASGf R cc3X9Gype 1O
2O ASzEESSL8 ASz Yit4 sel:Esealing9 pressureEsensitive9 a6ryli6Ebased ad4esive 6overed by a removable prote6tive stripk6omplying Yit4 ASGf R cc3X9Gype 1O

20" j 1 LCEATTL1 C zARK. GS

AO j ieldEapplied xa6l ets s4all 6omply Yit4 ASGf R M2c9Gype 19unless ot4erYise indi6atedO

BO TPR za6l et8 h ig4Empa6tEesistant9wPEesistant TPR 6omplying Yit4 ASGf C c5Qq9Rlass cX3" qERk t4i6l ness as s64eduledkroll sto6l ready :or s4op or :ield 6utting and :ormingO G4i6l ness is indi6ated in :ieldEapplied xa6l et s64edulesO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9provide produ6ts by one o: t4e :olloYing9or approved eWual8

aO zo4ns f anvillekZestonO
bO T0RROTlasti6s91n60j N SeriesO
6O Troto RorporationkLoSmoI eO
dO Speedline RorporationkSmoI eSa:eO

2O Ad4esive8 As re6ommended by xa6l et material manu:a6turerO
3O Rolor8 ; 4iteO
qO j a6toryEabri6ated :itting 6overs to mat64 xa6l et i: availablekot4erYise9:ield :abri6ateO

aO S4apes8 q" E and M0Edegree9 s4ortE and longEadius elboYs9 tees9 valves9 :langes9 unions9 redu6ers9 end 6aps9 soilEpipe 4ubs9 traps9 me64ani6al xoints9 and TErap and supply 6overs :or lavatoriesO

20X GAT. S

AO ASz Gape8 ; 4ite vaporEretarder tape mat64ing :a6toryEapplied xa6l et Yit4 a6ryli6 ad4esive9 6omplying Yit4 ASGf R cc3XO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO AB191deal Gape Civisionkq2QA; j ASzO
bO Avery Cennison Rorporation9Spe6ialty Gapes Civisionkj asson 0Q3XO
6O Rompa6 Rorporationkc0q and c0" O
dO Penture Gapekc" q0 R; Tlus9c" q2 R; Tlus9and c" q2 R; TlusHSVO

2O ; idt48 3 in64esO
3O G4i6l ness8 cc0 milsO
qO Ad4esion8 M0 oun6es :or6elHh64 in Yidt4O
" O . longation8 2 per6entO
XO Gensile Strengt48 q0 lb:Hih64 in Yidt4O
5O ASz Gape CisI s and SWuares8 Tre6ut disI s or sWuares o: ASz tapeO

205 S. Rw- . f . DGS

AO Bands8

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO 1G; 1nsulation SystemskNerrard Strapping and SealsO
bO - T- Trodu6ts91n60Q1nsulEf ate Strapping9Seals9and SpringsO

2O Stainless Steel8 ASGf A cX5 or ASGf A 2q0HA 2q0f 9Gype 30qk 0Q0c" in64 t4i6l 9 cH2 in64 Yide Yit4 Ying seal or 6losed sealO

BO Staples8 UutYardEGlin64ing insulation staples9nominal 3HqEn64EYide9stainless steel or f onelO

RO ; ire8 0Q0QEn64 ni6l elEGopper alloy 0Q0X2En64 so:tEannealed9 stainless steel 0Q0X2En64 so:tEannealed9 galvani&ed steelO

cO f anu:a6turers ESubxe6t to 6omplian6e Yit4 reWuirements9 provide produ6ts by one o: t4e :olloYing9 or approved eWual8

aO R) j ; ireO

TA- G3 E. ' . RwG1UD

3Q2 . ' Af 1DAG1UD

AO . , amine substrates and 6onditions :or 6omplian6e Yit4 reWuirements :or installation toleran6es and ot4er 6onditions a::e6ting per:orman6e o: insulation appli6ationO

cO Peri:y t4at systems to be insulated 4ave been tested and are :ree o: de:e6tsO
2O Peri:y t4at sur:a6es to be insulated are 6lean and dryO
3O Tro6eed Yit4 installation only a:ter unsatis:a6tory 6onditions 4ave been 6orre6tedO

3Q2 T- . TA- AG1UD

AO Sur:a6e Treparation8 Rlean and dry sur:a6es to re6eive insulationO - emove materials t4at Yill adversely a::e6t insulation appli6ationO

BO Sur:a6e Treparation8 Rlean and prepare sur:a6es to be insulatedOBe:ore insulating9apply a 6orrosion 6oating to insulated sur:a6es as :olloYs8

cO Stainless Steel8 Roat 300 series stainless steel Yit4 an epo, y primer " mils t4i6l and an epo, y :inis4 " mils t4i6l i: operating in a temperature range betYeen cq0 and 300 deg j ORonsult 6oating manu:a6turer :or appropriate 6oating materials and appli6ation met4ods :or operating temperature rangeO
2O Rarbon Steel8 Roat 6arbon steel operating at a servi6e temperature betYeen 32 and 300 deg j Yit4 an epo, y 6oatingO Ronsult 6oating manu:a6turer :or appropriate 6oating materials and appli6ation met4ods :or operating temperature rangeO

RO Roordinate insulation installation Yit4 t4e trade installing 4eat tra6ingO Romply Yit4 reWuirements :or 4eat tra6ing t4at apply to insulationO

CO f i, insulating 6ements Yit4 6lean potable Yaterk i: insulating 6ements are to be in 6onta6t Yit4 stainlessEsteel sur:a6es9use deminerali&ed YaterO

3Q3 N. D. - AL 1DSGALLAG1UD - . Vw1- . f . DGS

AO 1nstall insulation materials9 a66essories9 and :inis4es Yit4 smoot49 straig4t9 and even sur:a6esk :ree o: voids t4roug4out t4e lengt4 o: piping in6luding :ittings9valves9and spe6ialtiesO

BO 1nstall insulation materials9 :orms9 vapor barriers or retarders9 xa6l ets9 and t4i6l nesses reWuired :or ea64 item o: pipe system as spe6i:ied in insulation system s64edulesO

RO 1nstall a66essories 6ompatible Yit4 insulation materials and suitable :or t4e servi6eO 1nstall a66essories t4at do not 6orrode9so:ten9or ot4erYise atta6l insulation or xa6l et in eit4er Yet or dry stateO

CO 1nstall insulation Yit4 longitudinal seams at top and bottom o: 4ori&ontal runsO

. O 1nstall multiple layers o: insulation Yit4 longitudinal and end seams staggeredO

j O Co not Yeld bra6l ets96lips9or ot4er atta64ment devi6es to piping9:ittings9and spe6ialtiesO

NO Keep insulation materials dry during appli6ation and :inis4ingO

hO 1nstall insulation Yit4 tig4t longitudinal seams and end xointsO Bond seams and xoints Yit4 ad4esive re6ommended by insulation material manu:a6turerO

1O 1nstall insulation Yit4 least number o: xoints pra6ti6alO

zO ; 4ere vapor barrier is indi6ated9 seal xoints9 seams9 and penetrations in insulation at 4angers9 supports9 an64ors9and ot4er prox6tions Yit4 vaporEbarrier masti6O

cO 1nstall insulation 6ontinuously t4roug4 4angers and around an64or atta64mentsO
2O j or insulation appli6ation Y4ere vapor barriers are indi6ated9e, tend insulation on an64or legs :rom point o: atta64ment to supported item to point o: atta64ment to stru6tureO Gaper and seal ends at atta64ment to stru6ture Yit4 vaporEbarrier masti6O
3O 1nstall insert materials and install insulation to tig4tly xoin t4e insertO Seal insulation to insulation inserts Yit4 ad4esive or sealing 6ompound re6ommended by insulation material manu:a6turerO
qO Rover inserts Yit4 xa6l et material mat64ing adxa6ent pipe insulationO 1nstall s4ields over xa6l et9arranged to prote6t xa6l et :rom tear or pun6ture by 4anger9support9and s4ieldO

KO Apply ad4esives at manu:a6turer(s re6ommended 6overage rate and Yet and dry :ilm t4i6l nessesO

LO 1nstall insulation Yit4 :a6toryEapplied xa6l ets as :olloYs8

cO CraY xa6l et tig4t and smoot4O
2O Rover 6ir6um:erential xoints Yit4 3En64EYide strips9o: same material as insulation xa6l etO Se6ure strips Yit4 ad4esive and outYard 6lin64ing staples along bot4 edges o: strip9spa6ed q in64es o6O
3O Uverlap xa6l et longitudinal seams at least cEc42 in64esO 1nstall insulation Yit4 longitudinal seams at bottom o: pipeO Rlean and dry sur:a6e to re6eive sel:Esealing lapO Staple laps Yit4 outYard 6lin64ing staples along edge at 2 in64es o6O

aO j or beloYEambient servi6es9apply vaporEbarrier masti6 over staplesO

qO Rover xoints and seams Yit4 tape9a66ording to insulation material manu:a6turer(s Yritten instru6tions9to maintain vapor sealO
"O ; 4ere vapor barriers are indi6ated9apply vaporEbarrier masti6 on seams and xoints and at ends adxa6ent to pipe :langes and :ittingsO

f O Rut insulation in a manner to avoid 6ompressing insulation more t4an 5" per6ent o: its nominal t4i6l nessO

DO j inis4 installation Yit4 systems at operating 6onditionsO - epair xoint separations and 6ra6l ing due to t4ermal movementO

UO - epair damaged insulation :a6ings by applying same :a6ing material over damaged areasO . , tend pat64es at least q in64es beyond damaged areasO Ad4ere9staple9and seal pat64es similar to butt xointsO

TO j or aboveEambient servi6es9do not install insulation to t4e :olloYing8

cO PibrationE6ontrol devi6esO
2O Gesting agen6y labels and stampsO
3O Dameplates and data platesO
qO f an4olesO
"O h and4olesO
XO RleanoutsO

3Oq T. D. G- AG1UDS

AO 1nsulation 1nstallation at 1nterior ; all and Tartition Tenetrations JG4at Are Dot j ire - ated/8 1nstall insulation 6ontinuously t4roug4 Yalls and partitionsO

BO 1nsulation 1nstallation at j ireE- ated ; all and Tartition Tenetrations8 1nstall insulation 6ontinuously t4roug4 penetrations o: :ireEated Yalls and partitionsO

RO 1nsulation 1nstallation at j loor Tenetrations8

cO Tipe8 1nstall insulation 6ontinuously t4roug4 :loor penetrationsO
2O Seal penetrations t4roug4 :ireEated assembliesO Romply Yit4 reWuirements in Se6tion 05Qqc3 FTenetration j irestoppingGF

3O" N. D. - AL T1T. 1DSwLAG1UD 1DSGALLAG1UD

AO - eWuirements in t4is arti6le generally apply to all insulation materials e, 6ept Y4ere more spe6i:i6 reWuirements are spe6i:ied in various pipe insulation material installation arti6lesO

BO 1nsulation 1nstallation on j ittings9Palves9Strainers9j langes9and wnions8

cO 1nstall insulation over :ittings9 valves9 strainers9 :langes9 unions9 and ot4er spe6ialties Yit4 6ontinuous t4ermal and vaporEretarder integrity unless ot4erYise indi6atedO
2O 1nsulate pipe elboYs using pre:ormed :itting insulation or mitered :ittings made :rom same material and density as adxa6ent pipe insulationO . a64 pie6e s4all be butted tig4tly against adxoining pie6e and bonded Yit4 ad4esiveO j ill xoints9seams9voids9and irregular sur:a6es Yit4 insulating 6ement :inis4ed to a smoot494ard9and uni:orm 6ontour t4at is uni:orm Yit4 adxoining pipe insulationO
3O 1nsulate tee :ittings Yit4 pre:ormed :itting insulation or se6tional pipe insulation o: same material and t4i6l ness as used :or adxa6ent pipeO Rut se6tional pipe insulation to :itO Butt ea64 se6tion 6losely to t4e ne, t and 4old in pla6e Yit4 tie YireO Bond pie6es Yit4 ad4esiveO
qO 1nsulate valves using pre:ormed :itting insulation or se6tional pipe insulation o: same material9 density9 and t4i6l ness as used :or adxa6ent pipeO Uverlap adxoining pipe insulation by not less t4an tYo times t4e t4i6l ness o: pipe insulation9 or one pipe diameter9 Y4i64ever is t4i6l erO j or valves9 insulate up to and in6luding t4e bonnets9 valve stu::ingEbo, studs9 bolts9 and nutsO j ill xoints9seams9and irregular sur:a6es Yit4 insulating 6ementO
"O 1nsulate strainers using pre:ormed :itting insulation or se6tional pipe insulation o: same material9 density9 and t4i6l ness as used :or adxa6ent pipeO Uverlap adxoining pipe insulation by not less t4an tYo times t4e t4i6l ness o: pipe insulation9 or one pipe

diameter9Y4i64ever is t4i6l erOj ill xoints9seams9and irregular sur:a6es Yit4 insulating 6ementO 1nsulate strainers so strainer basI et :lange or plug 6an be easily removed and repla6ed Yit4out damaging t4e insulation and xa6l etO Trovide a removable reusable insulation 6overO j or beloYEambient servi6es9 provide a design t4at maintains vapor barrierO

XO 1nsulate :langes and unions using a se6tion o: oversi&ed pre:ormed pipe insulationO Uverlap adxoining pipe insulation by not less t4an tYo times t4e t4i6l ness o: pipe insulation9 or one pipe diameter9 Y4i64ever is t4i6l erO

5O Rover segmented insulated sur:a6es Yit4 a layer o: :inis4ing 6ement and 6oat Yit4 a masti6O 1nstall vaporEbarrier masti6 :or beloYEambient servi6es and a breat4er masti6 :or aboveEambient servi6esO - ein:or6e t4e masti6 Yit4 :abri6Eein:or6ing mes4O GroYel t4e masti6 to a smoot4 and YellEs4aped 6ontourO

QO j or servi6es not spe6i:ied to re6eive a :ieldEapplied xa6l et e, 6ept :or :le, ible elastomeri6 and polyole:in9 install :itted TPR 6over over elboYs9tees9strainers9valves9:langes9and unionsO Germinate ends Yit4 TPR end 6apsOGape TPR 6overs to adxoining insulation :a6ing using TPR tapeO

MO Sten6il or label t4e outside insulation xa6l et o: ea64 union Yit4 t4e Yord FunionG f at64 si&e and 6olor o: pipe labelsO

RO 1nsulate instrument 6onne6tions :or t4ermometers9pressure gages9pressure temperature taps9test 6onne6tions9 :loY meters9sensors9sYit64es9and transmitters on insulated pipesO S4ape insulation at t4ese 6onne6tions by tapering it to and around t4e 6onne6tion Yit4 insulating 6ement and :inis4 Yit4 :inis4ing 6ement9masti69and :las4ing sealantO

CO 1nstall removable insulation 6overs at lo6ations indi6atedO 1nstallation s4all 6on:orm to t4e :olloYing8

cO f aI e removable :lange and union insulation :rom se6tional pipe insulation o: same t4i6l ness as t4at on adxoining pipeO 1nstall same insulation xa6l et as adxoining pipe insulationO

2O ; 4en :lange and union 6overs are made :rom se6tional pipe insulation9e, tend insulation :rom :langes or union long at least tYo times t4e insulation t4i6l ness over adxa6ent pipe insulation on ea64 side o: :lange or unionO Se6ure :lange 6over in pla6e Yit4 stainlessEsteel or aluminum bandsO Sele6t band material 6ompatible Yit4 insulation and xa6l etO

3O Ronstru6t removable valve insulation 6overs in same manner as :or :langes9e, 6ept divide t4e tYoEpart se6tion on t4e verti6al 6enter line o: valve bodyO

qO ; 4en 6overs are made :rom blo6l insulation9mal e tYo 4alves9ea64 6onsisting o: mitered blo6l s Yired to stainlessEsteel :abri6O Se6ure t4is Yire :rame9Yit4 its atta64ed insulation9to :langes Yit4 tie YireO . , tend insulation at least 2 in64es over adxa6ent pipe insulation on ea64 side o: valveO j ill spa6e betYeen :lange or union 6over and pipe insulation Yit4 insulating 6ementO j inis4 6over assembly Yit4 insulating 6ement applied in tYo 6oatsO A:ter :irst 6oat is dry9apply and troYel se6ond 6oat to a smoot4 :inis4O

"O wnless a TPR xa6l et is indi6ated in :ieldEapplied xa6l et s64edules9:inis4 e, posed sur:a6es Yit4 a metal xa6l etO

30X 1DSGALLAG1UD Uj f 1D. - ALEj 1B. - 1DSwLAG1UD

AO 1nsulation 1nstallation on Straig4t Tipes and Gubes8

cO Se6ure ea64 layer o: pre:ormed pipe insulation to pipe Yit4 Yire or bands and tig4ten bands Yit4out de:orming insulation materialsO

2O ; 4ere vapor barriers are indi6ated9 seal longitudinal seams9 end xoints9 and protrusions Yit4 vaporE barrier masti6 and xoint sealantO

3O j or insulation Yit4 :a6toryEapplied xa6l ets on aboveEambient sur:a6es9se6ure laps Yit4 outYardEblin64ed staples at X in64es o6O

qO j or insulation Yit4 :a6toryEapplied xa6l ets on beloYEambient sur:a6es9 do not staple longitudinal tabsO 1nstead9se6ure tabs Yit4 additional ad4esive as re6ommended by insulation material manu:a6turer and seal Yit4 vaporEbarrier masti6 and :las4ing sealantO

BO 1nsulation 1nstallation on Tipe j langes8

cO 1nstall pre:ormed pipe insulation to outer diameter o: pipe :langeO

2O f aI e Yidt4 o: insulation se6tion same as overall Yidt4 o: :lange and bolts9plus tYi6e t4e t4i6l ness o: pipe insulationO

3O j ill voids betYeen inner 6ir6um:eren6e o: :lange insulation and outer 6ir6um:eren6e o: adxa6ent straig4t pipe segments Yit4 mineralEiber blanI et insulationO

qO 1nstall xa6l et material Yit4 manu:a6turer(s re6ommended ad4esive9 overlap seams at least c in649 and seal xoints Yit4 :las4ing sealantO

RO 1nsulation 1nstallation on Tipe j ittings and . lboYs8

cO 1nstall pre:ormed se6tions o: same material as straig4t segments o: pipe insulation Y4en availableO

2O ; 4en pre:ormed insulation elboYs and :ittings are not available9 install mitered se6tions o: pipe insulation9 to a t4i6l ness eWual to adxoining pipe insulationO Se6ure insulation materials Yit4 Yire or bandsO

CO 1nsulation 1nstallation on Palves and Tipe Spe6ialties8

cO 1nstall pre:ormed se6tions o: same material as straig4t segments o: pipe insulation Y4en availableO

2O ; 4en pre:ormed se6tions are not available9install mitered se6tions o: pipe insulation to valve bodyO

3O Arrange insulation to permit a66ess to pa6l ing and to alloY valve operation Yit4out disturbing insulationO

qO 1nstall insulation to :langes as spe6i:ied :or :lange insulation appli6ationO

305 j 1 LCEATTL1 C zARK. G 1DSGALLAG1UD

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300 j 1 LC VwAL1G7 RUDG- UL

AO Gesting Agen6y8 . ngage a Wuali:ied testing agen6y to per:orm tests and inspe6tionsO

BO Ter:orm tests and inspe6tionsO

RO Gests and 1nspe6tions8

cO 1nspe6t pipe9 :ittings9 strainers9 and valves9 randomly sele6ted by Ar64ite6t9 by removing :ieldE applied xa6l et and insulation in layers in reverse order o: t4eir installationO. , tent o: inspe6tion s4all be limited to t4ree lo6ations o: straig4t pipe9 t4ree lo6ations o: t4readed :ittings9 tYo lo6ations o: t4readed strainers9 t4ree lo6ations o: t4readed valves9 and t4ree lo6ations o: :langed valves :or ea64 pipe servi6eO

CO All insulation appli6ations Yill be 6onsidered de:e6tive ; orl i: sample inspe6tion reveals non6omplian6e Yit4 reWuirementsO

30M T1T1DN 1DSwLAG1UD SRh. CwL. 9N. D. - AL

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AO - e:er to Rontra6t CraYings

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Section 230900
Building Automation – Control Equipment

PART 1 - GENERAL

1.1 SUMMARY

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

B. ~~See Division 23 Section "Sequence of Operations for HVAC Controls"~~ Refer to Contract Documents controls sequences and points list for further requirements that relate to this Section.

1.2 SUBMITTALS

A. Product Data: For each control device indicated.

B. Shop Drawings:

1. Schematic flow diagrams.
2. Power, signal, and control wiring diagrams.
3. Details of control panel faces.
4. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
5. Control System Software: Schematic diagrams, written descriptions, and points list.

C. Software and firmware operational documentation.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

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

1.4 CONTRACTOR QUALIFICATIONS AND ADDITIONAL RESPONSIBILITIES

A. The Contractor's superintendent for BAS installation shall be satisfactory to the Owner and shall not be changed except with the consent of the Owner unless the superintendent proves to be unsatisfactory to the Contractor and ceases to be in his employ.

B. At a minimum, the Contractor must employ at least two Tridium N4 Certified technicians during the entire course of the BAS installation

C. No work shall be conducted by the contractor or their subcontractors unless the Contractor's supervisor is on site.

D. Safety and supervision is the responsibility of the Contractor.

E. The Contractor shall review existing electrical plans, if available, for any existing control systems and shall safe-off existing controls (pneumatic or electronic) and the BAS upgrade is being installed.

F. Electricity (power) and water required for the completion of the work shall be furnished by the Owner at existing fixtures or outlets. (The Owner will not provide any temporary pipes, cables, etc.)

G. Before commencing work, a coordination meeting shall be held with the Free Library and their Master Systems Integrator to establish expectations for the following:
   1. Equipment and Point naming standards
   2. Graphical display and other HMI standards
   3. Station Login and Passwords for Contractor use
   4. Software version compatibility

H. Contractor shall include one (1) day labor for working with Free Library's Master System Integrator to coordinate and demonstrate the installed BAS functionality and to activate the Supervisor connection to the local JACE.

~~1.5 MASTER SYSTEM INTEGRATOR RESPONSIBILITIES~~

~~A. The Master System Integrator (MSI) services are provided by Free Library at no cost to Contractor~~

~~B. MSI will assist Free Library with review of Contractor BAS submittals to confirm compliance with established standards~~

~~C. MSI shall establish and enforce the Free Library standards for the "look and feel" of BAS upgrades for library branches to maintain ease of monitoring and service by library personnel. This includes the standards for unit and point naming as well as graphical displays.~~

~~D. MSI will periodically visit the construction site as the owner's agent to check the progress of the BAS installation~~

~~E. MSI will coordinate IP addressing with Free Library IT department and establish the connection from the local JACE to the Niagara Supervisor enterprise platform.~~

~~F. MSI perform final integration to the Supervisor and issues a Report of Compliance to Free Library standards~~

SITE COORDINATION

~~1.6~~1.5 ~~The Contractor shall take into account that the building cannot be shut down in the course of completing the work. In the event that the work requires a shutdown of the building systems, the Contractor shall schedule work in such a manner as to limit the shutdown to a maximum of 48 hours. The contractor shall assume the 48-hour shutdown window will only occur over a weekend.~~

~~1.7~~1.6 Shutdown requests must be submitted in advance to Free Library's Project Manager

~~1.8~~1.7 ~~[OPTIONAL]~~ Staff Names: Within 7 days of Notice to Proceed, submit a list of the Contractor's principal staff assignments, including the Superintendent and other personnel in attendance at the site; identify individuals, their duties and responsibilities; list their addresses and telephone numbers.

~~1.9~~1.8 PROJECT CLOSEOUT

A. Documents to be included in the project completion submittal shall include:
   1. Contract document
   2. Product submittals.
   3. Operating and maintenance manual submittal.
   4. Submittal of warranties.
   5. Photo logs of the work.
   6. Report by Master Systems Integrator of compliance to Free Library standards

PART 2 - PRODUCTS

2.1 MANUFACTURERS/EQUIPMENT

A. Honeywell WEBs/Spyder Series
B. Johnson Controls FX/PCG Series

Note that ALL controllers provided as part of this contract **MUST** be of single source provider.

2.2 BUILDING AUTOMATION SYSTEM

A. The Building Automation System (BAS) shall be comprised of a network of interoperable, stand-alone digital controllers, network area controllers, graphics and programming and other control devices for a complete system as specified herein.

B. BAS shall also consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation (optional) permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device accessed via point-and-click graphics.

C. All unit controllers must exhibit pass-through programing from the server, through the local supervisor down to the individual unit controller. This to include modifications to PLC inset algorithms and point transfer.

2.3 DDC EQUIPMENT

A. Network Area Controller (NAC): The NAC will be the main integration and communication point for the BAS. It shall be a Honeywell WEB-8000 running Niagara version 4.9 or higher (acceptable alternate is a Johnson Controls FX-SC8). The NAC JACE shall be provided with a Device License sufficient to cover all known devices plus 20% spare for future considerations. Also included shall be sufficient network capability for the required number of LAN connections. Contract requirements shall be to provide complete BAS that will be compatible with Free Library's existing enterprise Niagara 4 Supervisor and Free Library BAS standards.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source. The following are requirements for system controllers:

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation.

2. All controllers shall have 32bit processor with 32-bit arithmetic logic units, CPU registers and data buses.

3. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Global communications.
    b. Discrete/digital, analog, and pulse I/O.
    c. Monitoring, controlling, or addressing data points.
    d. Software applications, scheduling, and alarm processing.
    e. Testing and developing control algorithms without disrupting field hardware and

controlled environment.

C. Programmable Controllers: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation.

D. I/O Expanders: Hardwired inputs and outputs may tie into system through expansion modules to controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0-to-10 VDC), current (4-to-20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation
5. Analog Outputs: Provide modulating signal, either low voltage (0-to-10 VDC) or current (4-to-20 mA)
6. Universal I/O: Provide software selectable binary or analog outputs.
7. ***NO*** tristate floating or pulse-width outputs permitted.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.

4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

2.5 ANALOG CONTROLLERS

A. Step Controllers: 6 or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. SCR Controllers: 4-20 ma/0-10 vdc electric modulating set point.

C. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.

D. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

E. ECM Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

2.6 TIME CLOCKS

A. Manufacturers:
1. Honeywell
2. Johnson Controls Inc.
3. Grasslin
4. Paragon

B. Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

C. Solid-state, programmable time control with 8 separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual

override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

2.7 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers

    a. Kele (allowed in conjunction with either JCI or Honeywell)
    b. Honeywell (Not to mix with Johnson Controls)
    c. Johnson Controls (Not to mix with Honeywell Controls)

2. Accuracy: Plus or minus 0.36 deg F at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches
5. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:

1. Manufacturers:
    a. Honeywell
    b. Johnson Controls, Inc.

2. Accuracy: Plus or minus 0.2 percent at calibration point.

3. Wire: Twisted, shielded-pair plenum-rated cable.
4. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
5. Room Sensor Cover Construction: Manufacturer's standard locking covers.
6. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

D. Pressure Transmitters/Transducers:

1. Manufacturers:
    a. Honeywell
    b. Johnson Controls.
    c. Veris

2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
b. Output: 4-to-20 mA.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4-to-20 mA.

2.8 STATUS SENSORS

A. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.

B. Current Sensor: A device that detects electric current in a wire and generates a signal proportional to that current.

C. Current Transducer: A device that coverts alternating or direct electrical **current** signals into analog instrumentation signals so that they can be used and readily interpreted by certain industrial control systems.

D. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

E. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

F. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

G. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

2.9 CONTROL CABLE

A. MS/TP communication wiring shall be Belden 16/18 AWG shielded plenum-rated twisted pair or approved equal.
B. Sensor/device wiring shall be 18 AWG twisted, shielded, plenum-rated cable of sufficient conductors as required
C. Ethernet cabling for IP communication from the server/supervisor shall be CAT6e.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

B. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

C. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable free air.
4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.3 FIELD QUALITY CONTROL

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

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

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.
8. Test that alerts and alarm notifications go through to the intended recipient(s)

C. DDC Verification:

1. Verify that peripheral devices are installed before calibration, testing, and loop or leak checks.
2. Check devices for proper location and accessibility.
3. Check device installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check device tubing for proper fittings, slope, material, and support.
5. Check pressure devices for piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature sensors for proper length of sensing elements.
7. Check control valve installation particulars. Verify full range of operation.
8. Check electronic damper actuators. Verify full stroke, proper blade alignment, and smooth non-binding operation
9. Check DDC system as follows:

    a. Verify that DDC controller power supply is from normal power supply with surge protection.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Training shall be provided in (2) 4-hour sessions with (1) 2-hour follow -up session 6 months once substantial completion has

been reached.

END OF SECTION 230900

Section 230923
Direct Digital Control (DDC) System For HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:

1. Section 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.
2. Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.
3. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.
4. Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.
5. Section 230923.43 "Weather Stations" for weather stations that connect to DDC systems.
6. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
7. Communications Cabling:

    a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.

8. Raceways:

    a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.

9. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.

1.3 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. E/P: Voltage to pneumatic.

L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

M. HLC: Heavy load conditions.

N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

O. I/P: Current to pneumatic.

P. LAN: Local area network.

Q. LNS: LonWorks Network Services.

R. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark International for configuration properties.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.
13. TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "U-Keep-It." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

S. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

T. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

U. Modbus TCP/IP: An open protocol for exchange of process data.

V. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

W. MTBF: Mean time between failures.

X. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

Y. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Z. Peer to Peer: Networking architecture that treats all network stations as equal partners.

AA. POT: Portable operator's terminal.

BB. PUE: Performance usage effectiveness.

CC. RAM: Random access memory.

DD. RF: Radio frequency.

EE. Router: Device connecting two or more networks at network layer.

FF. Server: Computer used to maintain system configuration, historical and programming database.

GG. TCP/IP: Transport control protocol/Internet protocol.

HH. UPS: Uninterruptible power supply.

II. USB: Universal Serial Bus.

JJ. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

KK. VAV: Variable air volume.

LL. WLED: White light emitting diode.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

    a. Workstations.
    b. Servers.
    c. Printers.
    d. Gateways.
    e. Routers.
    f. Protocol analyzers.
    g. DDC controllers.
    h. Enclosures.
    i. Electrical power devices.
    j. UPS units.
    k. Accessories.
    l. Instruments.
    m. Control dampers and actuators.
    n. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.

3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:

1. General Requirements:

    a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
    b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
    c. Drawings Size: 11x17.

2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:

    a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
    b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
    c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
    d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
    e. Network communication cable and raceway routing.
    f. Information, drawn to scale, of <Insert requirements>.
    g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

6. Schematic drawings for each controlled HVAC system indicating the following:

a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
c. A graphic showing location of control I/O in proper relationship to HVAC system.
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
g. Narrative sequence of operation.
h. Graphic sequence of operation, showing all inputs and output logical blocks.

7. Control panel drawings indicating the following:

a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
c. Front, rear, and side elevations and nameplate legend.
d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:

a. Each device connected to network with unique identification for each.
b. Interconnection of each different network in DDC system.
c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches and transmitters.
d. Process signal tubing to sensors, switches and transmitters.
e. Pneumatic main air and control signal tubing to pneumatic [damper] [and] [valve] actuators, pilot-positioners if applicable, and associated transducers.

11. Color graphics indicating the following:

    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

    a. Loss of power.
    b. Loss of network communication signal.
    c. Loss of controller signals to inputs and outpoints.
    d. Operator workstation failure.
    e. Server failure.
    f. Gateway failure.
    g. Network failure
    h. Controller failure.
    i. Instrument failure.
    j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

F. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

    a. Flow at Project design and minimum flow conditions.
    b. Face velocity at Project design and minimum airflow conditions.
    c. Pressure drop across damper at Project design and minimum airflow conditions.
    d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
    e. Maximum close-off pressure.
    f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
    g. Torque required at worst case condition for sizing actuator.
    h. Actuator selection indicating torque provided.
    i. Actuator signal to control damper (on, close or modulate).
    j. Actuator position on loss of power.
    k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

    a. Flow at Project design and minimum flow conditions.
    b. Pressure-differential drop across valve at Project design flow condition.
    c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
    d. Design and minimum control valve coefficient with corresponding valve position.
    e. Maximum close-off pressure.
    f. Leakage flow at maximum system pressure differential.
    g. Torque required at worst case condition for sizing actuator.
    h. Actuator selection indicating torque provided.
    i. Actuator signal to control damper (on, close or modulate).
    j. Actuator position on loss of power.
    k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

    a. Instrument flow range.
    b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
    c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
    d. Pressure-differential loss across instrument at Project design flow conditions.
    e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Systems Provider Qualification Data:

2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

B. Welding certificates.

C. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

D. Product Test Reports: For each product that requires testing to be performed by manufacturer.

E. Preconstruction Test Reports: For each separate test performed.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For manufacturer's warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers' recommended parts lists for proper product operation over four - year period following warranty period. Parts list shall be indicated for each year.

C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during two-year period following warranty period.

D. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:

1. Network Controller: One.
2. Programmable Application Controller: One.
3. Application-Specific Controller: One.
4. Carbon Dioxide Sensor and Transmitter: One.
5. Moisture Sensor and Transmitter: One.
6. Pressure Sensor and Transmitter: One.
7. Room Temperature Sensor and Transmitter: One.
8. General-Purpose Relay: One.
9. Multifunction Time-Delay Relay: One.
10. Latching Relay: One.
11. Current-Sensing Relay: One.
12. Combination On-Off Status Sensor and On-Off Relay: One.
13. Transformer: One.
14. DC Power Supply: One.
15. Supply of 20 percent spare optical fiber cable splice organizer cabinets for several re-terminations.

1.9 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.
    c. Product manufacturing, testing and quality control.
    d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
    e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 50 miles of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope and value.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
8. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

D. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

a. For Gateway: Two-year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Alerton Controls, Inc.
2. Automated Logic Corporation

3. Delta Control, Inc.
4. Johnson Controls Inc.
5. Seimens Industries
6.

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

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

2.3 WEB ACCESS

A. DDC system shall be Web based or Web compatible.

1. Web-Based Access to DDC System:

a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
c. Web access shall be password protected.

2. Web-Compatible Access to DDC System:

a. Workstation and server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design DDC system to satisfy requirements indicated.

B. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

    a. DDC system shall manage HVAC systems.
    b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
    c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
    d. DDC system shall operate while unattended by an operator and through operator interaction.
    e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

C. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

D. DDC System Speed:

1. Response Time of Connected I/O:

    a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
    b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
    c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
    d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.

2. Display of Connected I/O:

    a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
    b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
    c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.
    d. Graphic display refresh shall update within four seconds.
    e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

E. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

F. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. Local Storage:

    a. Provide server with data storage indicated. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

3. Cloud Storage:

    a. Provide application-based and web browser interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

G. DDC Data Access:

1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

H. Future Expandability:

1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

I. Input Point Displayed Accuracy: Input point displayed values shall meet values identified on the Contract Documents.

J. Precision of I/O Reported Values: Values reported in database and displayed shall meet the values identified on the Contract Documents.

K. Control Stability: Control variables meet the values identified on the Contract Documents.

L. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

    a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance.

Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: [Type 2] [Type 3] [Type 12] <Insert type>.
b. Outdoors, Unprotected: [Type 4] [Type 4X].
c. Indoors, Heated with Filtered Ventilation: [Type 1] [Type 2] <Insert type>.
d. Indoors, Heated with Non-Filtered Ventilation: [Type 2] [Type 12] <Insert type>.
e. Indoors, Heated and Air Conditioned: [Type 1] <Insert type>.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: [Type 12] [Type 4] [Type 4X] <Insert type>.
2) Air-Moving Equipment Rooms: [Type 1] [Type 2] [Type 12] <Insert type>.

g. Localized Areas Exposed to Washdown: [Type 4] [Type 4X] <Insert type>.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [Type 2] [Type 3] [Type 12] <Insert type>.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [Type 4] [Type 4X] <Insert type>.
j. Hazardous Locations: Explosion-proof rating for condition.
k. <Insert location and enclosure requirements>.

M. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated[, cooled] and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: [Type 2] [Type 3] [Type 12] <Insert type>.
b. Outdoors, Unprotected: [Type 4] [Type 4X].
c. Indoors, Heated with Filtered Ventilation: [Type 1] [Type 2] <Insert type>.
d. Indoors, Heated with Non-Filtered Ventilation: [Type 2] [Type 12] <Insert type>.
e. Indoors, Heated and Air-conditioned: [Type 1] <Insert type>.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: [Type 12] [Type 4] [Type 4X] <Insert type>.

2) Air-Moving Equipment Rooms: [Type 1] [Type 2] [Type 12] <Insert type>.

g. Localized Areas Exposed to Washdown: [Type 4] [Type 4X] <Insert type>.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [Type 2] [Type 3] [Type 12] <Insert type>.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [Type 4] [Type 4X] <Insert type>.
j. Hazardous Locations: Explosion-proof rating for condition.
k. <Insert location and enclosure requirements>.

N. DDC System Reliability:

1. Design, install and configure DDC controllers, gateways, routers, and] < to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value shall include any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

O. Electric Power Quality:

1. Power-Line Surges:

a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
b. Do not use fuses for surge protection.
c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

P. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

Q. UPS:

1. DDC system products powered by UPS units shall include the following:

a. Desktop workstations.
b. Printers.
c. Servers.
d. Gateways.
e. DDC controllers.

R. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than three levels of LANs.

1. Level one LAN shall connect network controllers and operator workstations.
2. Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.
3. LAN Connecting Application-Specific Controllers: 115,000 bps.

C. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

D. System architecture shall perform modifications without having to remove and replace existing network equipment.

E. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

F. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

G. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
5. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Security system command center.
3. Fire-alarm system command center.
4. Where indicated on Contract Documents

D. Desktop Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system Level two or Level three LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level one LAN.
5. Connect to system through a cellular data service.
6. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.

7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
8. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected or with LAN.

G. Mobile Device:

1. Connect to system through a wireless router connected to LAN and cellular data service.
2. Able to communicate with any DDC controller connected to DDC system using a dedicated application and secure web access.

H. Telephone Communications:

1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.
2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.

a. Desktop and Portable Workstations:

1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
2) Have routines to automatically answer calls, and either file or display information sent remotely.
3) Communications taking place over telephone lines shall be completely transparent to operator.
4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.

b. DDC Controllers:

1) Not have modems unless specifically indicated for a unique controller.
2) Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
3) Analyze and prioritize alarms to minimize initiation of calls.
4) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
5) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
6) Call default devices when communications cannot be established with primary devices.

I. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

J. Simultaneous Operator Use: Capable of accommodating up to [five] [10] [20] <Insert number> simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.7 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. EIA-485A.
4. IP.
5. IEEE 8802-3, Ethernet.

2.8 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.

4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.9 DDC SYSTEM WIRELESS NETWORKS

A. Use Zigbee or an open industry standard and technology used by multiple DDC system manufacturers technology to create a wireless mesh network to provide wireless connectivity for network devices at multiple system levels including communications from programmable application controllers and application-specific controllers to temperature sensors and from network controllers to programmable application controllers and application-specific controllers.

B. Installer shall design wireless networks to comply with DDC system performance requirements indicated. Wireless network devices shall co-exist on same network with hardwired devices.

C. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.

D. A wireless coordinator shall provide a wireless interface between programmable application controllers, application-specific controllers, and network controllers.

E. Wireless Coordinators:

1. Each wireless mesh network shall use wireless coordinator(s) for initiation and formation of network.
2. Use direct sequence spread spectrum RF technology.
3. Operate on the 2.4-GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Operate as a bidirectional transceiver with sensors and routers to confirm and synchronize data transmission.
7. Capable of communication with sensors and routers up to a maximum distance of 250 feet in line of sight.
8. Include visual indicators to provide diagnostic information required for operator verification of operation.

F. Wireless Routers:

1. Each wireless mesh network shall use wireless routers with any controller to provide a wireless interface to a network controller, through a wireless coordinator.
2. Use direct sequence spread spectrum RF technology.
3. Operate on the 2.4-GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.
7. Capable of communication with other mesh network devices at a maximum distance of 250 feet in line of sight.
8. Include indication for use in commissioning and troubleshooting.

G. Wireless Temperature Sensors:

1. Wireless temperature sensors shall sense and transmit room temperatures, temperature set point, room occupancy notification and low battery condition to an associated router.

2. Use direct sequence spread spectrum RF technology.
3. Operate on the 2.4-GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to CFR 15, Subpart B, Class A.
6. Include set point adjustment between 55 to 85 deg F.
7. Multiple sensors shall be able to report to a router connected to a DDC controller for averaging or high and low selection.

H. One-to-One Wireless Network Receivers:

1. One-to-one wireless receivers shall receive wireless RF signals containing temperature data from multiple wireless room temperature sensors and communicate information to programmable application controllers or application-specific controllers.

    a. Use direct sequence spread spectrum RF technology.
    b. Operate on the 2.4-GHz ISM Band.
    c. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
    d. FCC compliant to 47 CFR 15, Subpart B, Class A.
    e. Operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.
    f. Capable of communication up to a distance of 200 feet.
    g. Include visual indication of the following:

        1) Power.
        2) Receiver activity.
        3) Wireless RF transmission from wireless sensors.
        4) No transmission, weak signal, adequate signal or excellent signal.

I. One-to-One Wireless Network Sensors:

1. One-to-one wireless sensors shall sense and report room temperatures to one-to-one receiver.

    a. Use direct sequence spread spectrum RF technology.
    b. Operate on the 2.4-GHz ISM Band.
    c. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
    d. FCC compliant to CFR 15, Subpart B, Class A.
    e. Include set point adjustment between 55 to 85 deg F.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 32- or 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.

4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:

    a. Operator access to DDC system shall be under password control.
    b. An alphanumeric password shall be field assignable to each operator.
    c. Operators shall be able to access DDC system by entry of proper password.
    d. Operator password shall be same regardless of which computer or other interface means is used.
    e. Additions or changes made to passwords shall be updated automatically.
    f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
    g. Software shall have at least five access levels.
    h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
    i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Data Segregation:

    a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
    b. Include at least 32 segregation groups.
    c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
    d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
    e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
    f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

8. Operators shall be able to perform commands including, but not limited to, the following:

    a. Start or stop selected equipment.
    b. Adjust set points.
    c. Add, modify, and delete time programming.
    d. Enable and disable process execution.
    e. Lock and unlock alarm reporting for each point.
    f. Enable and disable totalization for each point.
    g. Enable and disable trending for each point.
    h. Override control loop set points.
    i. Enter temporary override schedules.
    j. Define holiday schedules.
    k. Change time and date.
    l. Enter and modify analog alarm limits.
    m. Enter and modify analog warning limits.
    n. View limits.
    o. Enable and disable demand limiting.
    p. Enable and disable duty cycle.
    q. Display logic programming for each control sequence.

9. Reporting:

    a. Generated automatically and manually.
    b. Sent to displays, printers and disk files.
    c. Types of Reporting:

        1) General listing of points.
        2) List points currently in alarm.
        3) List of off-line points.
        4) List points currently in override status.
        5) List of disabled points.
        6) List points currently locked out.
        7) List of items defined in a "Follow-Up" file.
        8) List weekly schedules.
        9) List holiday programming.
        10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.

4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
    c. Keyboard equivalent shall be available for those operators with that preference.

20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. On-line context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.

        1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed

word-processing program, which shall run concurrently with operating system software.

c. Available for Every Menu Item:

1) Index items for each system menu item.

22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols[similar to those indicated].
b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

1) Define background screens.
2) Define connecting lines and curves.
3) Locate, orient and size descriptive text.
4) Define and display colors for all elements.
5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

a. Room layouts with room identification and name.
b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation].
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways operator workstations and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:

a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
f. Point related change capability shall include the following:

    1) System and point enable and disable.
    2) Run-time enable and disable.
    3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
    4) Assignment of alarm and warning limits.

g. Application program change capability shall include the following:

    1) Enable and disable of software programs.
    2) Programming changes.
    3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:

    a. Proportional control (P).
    b. Proportional plus integral (PI).
    c. Proportional plus integral plus derivative (PID).
    d. Adaptive and intelligent self-learning control.

        1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
        2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

    a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
    b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
    c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
    d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.

    a. Class 1:

        1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

    b. Class 2:

        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.

    c. Class 3:

1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on workstation and server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

1. .

J. Utility Reports: Prepare Project-specific reports.

1. Electric Report:

a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
c. Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.
e. For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.

2. Natural Gas Report:

a. Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
b. Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
c. Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.
d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
e. For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.

K. Energy Reports: Prepare Project-specific daily, weekly, monthly and annual energy reports.

1. Prepare report for each purchased energy utility, indicating the following:

a. Time period being reported with beginning and end date, and time indicated.
b. Consumption in units of measure commonly used to report specific utility consumption over time.
c. Gross area served by utility.
d. Consumption per unit area served using utility-specific unit of measure.
e. Cost per utility unit.
f. Utility cost per unit area.
g. Convert all utilities to a common energy consumption unit of measure and report for each utility.
h. Consumption per unit area using common unit of measure.

2. Prepare purchased energy utility report for each submetered area that indicates the following:

a. Time period being reported with beginning and end date, and time indicated.
b. Gross area served.
c. Energy consumption by energy utility type.

d. Energy consumption per unit area by energy utility type.
e. Total energy consumption of all utilities in common units of measure.
f. Total energy consumption of all utilities in common units of measure per unit area.
g. Unit energy cost by energy utility type.
h. Energy cost by energy utility type.
i. Energy cost per unit area by energy utility type.
j. Total cost of all energy utilities.
k. Total cost of all energy utilities per unit area.

3. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report shall indicate the following:

a. Time period being reported with beginning and end date, and time indicated.
b. Gross area served.
c. Energy consumption by energy utility type.
d. Energy consumption per unit area by energy utility type.
e. Total energy consumption of all utilities in common units of measure.
f. Total energy consumption of all utilities in common units of measure per unit area.
g. Unit energy cost by energy utility type.
h. Energy cost by energy utility type.
i. Energy cost per unit area by energy utility type.
j. Total cost of all energy utilities.
k. Total cost of all energy utilities per unit area.

L. Weather Reports:

1. Include weekly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Daily minimum, maximum, and average outdoor dew point temperature.
d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F.
f. Weekly minimum, maximum, and average outdoor carbon dioxide level.
g. Daily minimum, maximum, and average relative humidity.
h. Daily minimum, maximum, and average barometric pressure.
i. Daily minimum, maximum, and average wind speed and direction.

2. Include monthly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Daily minimum, maximum, and average outdoor dew point temperature.
d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F.
f. Monthly minimum, maximum, and average outdoor carbon dioxide level.
g. Daily minimum, maximum, and average relative humidity.
h. Daily minimum, maximum, and average barometric pressure.
i. Daily minimum, maximum, and average wind speed and direction.

M. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

N. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

O. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be one of the following:

    a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

        1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
        2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

    b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
    c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

P. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.

2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:

    a. Backup.
    b. Purge.
    c. Restore.

4. Database management software shall support the following:

    a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
    b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
    c. Backup: Include means to create a database backup file and select a storage location.
    d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

5. Database management software shall include information of current database activity, including the following:

    a. Ready.
    b. Purging record from a database.
    c. Action failed.
    d. Refreshing statistics.
    e. Restoring database.
    f. Shrinking a database.
    g. Backing up a database.
    h. Resetting Internet information services.
    i. Starting network device manager.
    j. Shutting down the network device manager.
    k. Action successful.

6. Database management software monitoring functions shall continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window shall have the following sections:

    a. Allow operator to set and review scan intervals and start times.
    b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
    c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
    d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
    e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.

9. Monitoring settings taskbar shall include the following informational icons:

    a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
    b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
    c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

2.11 OFFICE APPLICATION SOFTWARE

A. Include current version of office application software at time of Substantial Completion.

B. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."

1. Database.
2. E-mail.
3. Presentation.
4. Publisher.
5. Spreadsheet.
6. Word processing.

2.12 MAINTENANCE MANAGEMENT SOFTWARE

A. Scope:

1. Include complete and functional software-driven maintenance management system. Software shall perform scheduling of preventive maintenance and generation of work orders, for mechanical and electrical equipment and systems.
2. Work orders shall be automatically generated from alarm conditions, run time, and calendar time. Each work order generated shall list parts, tools, craftspeople, and define task to be performed.
3. Work order generated shall be used to schedule a repair or preventive maintenance routine.
4. Work order shall be used to track completion of work, parts used and total cost of repair.
5. A database shall include an inventory tracking system. Work orders generated shall automatically update inventory database to show quantity of tools, repair parts and expendables used for a work order.
6. Work orders and preventive maintenance schedules shall be printed on a dedicated printer assigned solely to maintenance management function.

B. Additional Hardware Requirements:

1. Maintenance management software shall not require additional hardware, except for an additional printer that is dedicated to maintenance management.
2. Maintenance management software shall be integrated into DDC system.

C. Software Requirements:

1. From main menu of maintenance management system, it shall be possible through selection of icons to penetrate to individual functions described below.
2. Work Orders:

    a. Automatically generate work orders initiated from alarm conditions, accumulated run time or calendar time. Work orders generated shall specify a particular task to be accomplished including the labor, material and tools needed to accomplish work.
    b. Include at least two of the following types of work orders:

        1) Corrective and emergency maintenance work orders shall be generated for a specific job or repair for emergency, breakdown, or scheduled work.
        2) Preventive maintenance that are used on a periodic basis to generate preventive maintenance work orders.

    c. Include the following functions:

        1) Work Order Tracking: Perform every function related to processing work orders including creating, approving and initiating work orders, checking their status history and closing or reworking them when appropriate.
        2) Work Requests: Report any problems that require corrective maintenance activity generated by dispatchers and those people designated to request work orders.
        3) Quick Reporting: Report work done on an open work order or a small job.
        4) Work Manager: Specify the type of labor to be applied to a specific work order at specific times. It shall include the capability to dispatch one or more laborers to top-priority jobs on as-needed basis and to interrupt work in progress to reassign labor to higher priority tasks.

    d. Reports:

        1) Daily Maintenance Schedule by Supervisor: List a schedule of open work orders for a specified date by supervisor.
        2) Equipment Cost Roll-up Report: Include a roll-up of equipment costs incurred since the date the report was last run.
        3) Delinquent Work Order Report: List open work orders whose target completion date is earlier than the date the report is run.
        4) Employee Job Assignments: List labor codes that have job assignments for the specified date.
        5) Daily Work Order Assignment: List work orders that have labor assignments for the specified date.
        6) Estimated versus Actual Work Order Costs: List a cost summary of outstanding work orders.
        7) Open Work Orders Report: List open work orders for locations and equipment.

3. Inventory:

    a. Include an inventory tracking system to keep track of stocked, non-stocked and special-order items.
    b. Link inventory tracking to database and when items are consumed, as noted on a work order issued by system, inventory of stocked items shall be automatically updated.
    c. Include the following functions:

1) Inventory Control: Enter, display, and update information on each inventory item. It shall allow viewing of master inventory records that are independent of storeroom locations or item/location records. Include a screen that lists inventory transactions that move items in or out of inventory or from one storeroom location to another. Minimum information tracked shall include the following:

    a) Vendors supply items.
    b) Item balances, including the bin and lot level for each storeroom location.
    c) Alternative items.

2) Issues and Transfers: Issue stock directly from inventory, with or without a work order. When transfer of stock from one location to another location occurs, provide appropriate adjustments in stock balance record. Include a trace record of stock transfers from one storeroom to another.
3) Item Assembly Structures: Include modeling of equipment with inventory items and building of equipment and location hierarchies.
4) Metered Material Usage:

    a) Track usage by a piece of equipment.
    b) Record against a standing work order for a selected piece of equipment.
    c) Material usage transaction shall be written for each item of material used and be provided as an input to calculation for per unit material consumption report for a piece of equipment.

d. Reports:

1) Inventory Analysis Report: List for a given storeroom location, inventory items analysis information that allows quick identification of which inventory items represent greatest monetary investment for dollar value and rate of turnover.
2) Inventory Cycle Count Report: List for a specified storeroom, inventory items that are due to be cycle-counted, based on cycle-count frequency and last count date.
3) Economic Order Quantity Report: For a given storeroom location, display optimum economic ordering quantity for items in selected results set.
4) Inventory Pick Report: A pick list, by work order for items needed to be pulled from a designated storeroom's inventory for work orders having a target start date of specified date.
5) Suggested Order Report: List inventory items in selected results set that are due to be recorded, for a specified storeroom location, based on the following calculation: Suggest a reorder if current balance minus reserve quantity plus on-order quantity is less than reorder point.
6) Reorder Point Report: List selected set of items and optimum minimum level to have in stock based on demand, lead delivery time and a reserve safety stock.
7) Inventory Valuation Report: Gives an accounting of cost of current inventory, for inventory records in a designated storeroom location.
8) Item Order Status: Lists items on order.
9) List of Expired Items: Lists expired lot items in a storeroom. Report shall include item number, description, expiration date, bin number, lot number, manufacturer lot number, and quantity of expired items in that lot and bin.

10) Item Availability at All Locations: Lists alternative storeroom locations for selected items.
11) Where Used Report: List equipment on which item is recorded as being used.

4. Equipment:

a. Include equipment and location records; establish relationships between equipment, between locations, and between equipment and locations; track maintenance costs; and enter and review meter readings.
b. Include the following functions:

1) Equipment: Store equipment numbers and corresponding information including equipment class, location, vendor, up/down status and maintenance costs for each piece of equipment. Include building of equipment assemblies. Equipment assemblies hierarchical ordering shall be provided for arrangement of buildings, departments, equipment and sub-assemblies.
2) Operating Locations: Facilitate creation of records for operating locations of equipment, and track equipment that is used in multiple locations. In addition, allow hierarchical organization of equipment operating in facility by means of grouping equipment locations into areas of responsibility.
3) Failure Codes: Develop and display failure hierarchies to acquire an accurate history of types of failures that affect equipment and operating locations.
4) Condition Monitoring: Display time related or limit measurements recorded for a piece of equipment. It shall be possible to generate work orders from this screen and to take immediate action on problem conditions.

c. Reports:

1) Availability Statistic by Location: List equipment availability by location over a user-specified time period.
2) Equipment Failure Summary: List total number of failures by problem code for a piece of equipment for a specified time period.
3) Detailed Equipment Failure Report by Equipment: List of failure reports for the current piece of equipment for a specified time period.
4) Equipment Hierarchy Report: List of equipment.
5) Equipment History Graphs: Include a graphical report in histogram format that displays equipment breakdown history over a specified period.
6) Equipment Measurement Report: Tabular listing and description of each measurement point for a piece of equipment and the history of measurements taken for that point.
7) Maintenance Cost by Equipment: List of transactions costs for elected equipment in the specified date range.
8) Failure Count by Equipment: Graphically report the number of failures for each piece of equipment showing number of failures for each piece of equipment over a specified time period, occurrence of each problem code within set of failures and failures by problem code.
9) Failure Analysis Graphs: Graphically report number of failures for each piece of equipment over a specified time period, number of occurrences of each problem code within set of failures and failures by problem code.
10) Failure Code Hierarchy Report: List of failure codes in each level of the failure hierarchy.
11) Location Failure Summary: A summary for each selected location of failures reported and any hierarchy level locations for specified time period.

12) Failure Summary by Location: A summary of failures for the selected location and their subordinate locations that are part of the hierarchical system.
13) Detailed Failure Report by Location: List all failures for selected location and its subordinate locations that are part of a hierarchical system.
14) Maintenance Cost by System: List of total costs reported in a given date range for locations in selected hierarchical system.
15) Location Hierarchy Report: Lists member locations of a hierarchical system displayed in hierarchical fashion.

5. Purchasing:

a. Include preparation and generation of purchase requisitions and purchase orders; to report receipt of both items and services, match invoices with purchase orders and receipts and define and convert foreign currencies.
b. Include the following functions:

1) Purchase Requisition: Create and process purchase requisitions for items and services.
2) Purchase Orders: Create and process purchase orders for items and services from scratch or from purchase requisitions. Record receipts of items and services.
3) Invoices: Include functionality to match purchase orders with invoices and receipts. It shall also be possible to match a service receipt to an invoice. Project for entering of an invoice for bills that do not require purchase orders or receipts.
4) Currency Management: Define currencies and specify exchange rates. Include preparation of purchase requisitions and purchase orders in currency of vendor, while tracking costs in systems base currency.

c. Reports:

1) Invoice Approval Report: Include an approval form for entered invoices.
2) Inventory Receipts Register: List purchase orders and inventory received for the user-specified time frame.
3) Direct Purchase Back-Order Report: List of items ordered as a direct purchase not received by the required delivery date.
4) Standard Purchase Order: A printing of primary purchase order with vendors shipping information, and items purchased.
5) Purchase Order Status Report: List of purchase orders whose status has changed during a certain time period.
6) Standard Purchase Requisition: A printing of primary purchase requisition, including vendor name and shipping information.

6. Job Plans:

a. Include creation of a detailed description of work to be performed by a work order. The job plan shall contain operations, procedures and list of estimated material, labor and tools required for work.

7. Labor:

a. Store information on employees, contractors, and crafts and include the following functions:

1) Labor: Create, modify and view employee records. Employee records shall contain pay rate, overtime worked, overtime refused, specials skills and certifications.
2) Crafts: Create, modify and view craftspeople records.
3) Labor Reporting: Report labor usage by employee or craft externally from the work orders module.

b. Reports:

1) Employee Attendance Analysis: List of planned attendance, actual attendance, vacation and sick time in hours as a percentage of planned attendance for selected employees for specified time period.
2) Labor Productivity Analysis: List of actual labor hours by labor report category showing each by percentage.
3) Labor Availability versus Commitments by Crafts: A graphical report that details available labor hours versus committed work order hours by craft and day.

8. Calendars:

a. Establish calendar records indicating working time for equipment, location, craft, and labor records.

9. Resources:

a. Include entry and retrieval of data associated with resources required to maintain facility and to include the following functions:

1) Companies: Establish and update data on vendors and other companies.
2) Tools: Create and maintain information on the tools used on jobs. The information contained within this module shall be available to job plans and work orders.
3) Service Contracts: Specify information on service contracts with vendors or manufacturers.

10. Custom Applications:

a. Include creation of customized database tables and application screens that supplement functions specified.

11. Setup:

a. Include configuration of database, security and setup applications.
b. Perform the following functions:

1) Reports and Other Applications: Register reports and other applications for use within system.
2) Documents: Enter, track and link information from Drawings to equipment and inventory items.
3) Chart of Accounts: Add or modify accounts; set up financial periods; enter inventory accounts, company accounts, and resource recovery accounts; and define tax codes and rates.

4) Signature Security: Establish each user's access rights to modules, applications, screens and options.
5) Database Configuration: Customize database, including adjusting field lengths and modifying data types.
6) Application Setup: Change position of icons and menu items on the main menu screen.
7) Application Launching: Allow for connecting of third-party applications to data fields and push buttons.

12. Utilities:

a. Include utilities module that allows system administrator to customize system and to maintain database.
b. Include the following functions:

1) Interactive SQL: Include access to database for database management functions of import/export and backup.
2) Edit Windows: Display a dialog box to customize an application.
3) Archive Data: Remove records from database and store them for future reference.

D. Documentation:

1. Include complete documentation for the system consisting of a User Manual and Systems Administrator Guide.
2. User Manual shall describe how to use each application module and screen with step-by-step instructions detailing entry and retrieval of data for functions specified.
3. Include a step-by-step description of how each report is defined and retrieved.
4. Bind documentation and clearly title it indicating volume number and use.

2.13 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.

4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.14 ASHRAE 135 PROTOCOL ANALYZER

A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.

B. Analyzer shall include the following minimum capabilities:

1. Capture and store to a file data traffic on all network levels.
2. Measure bandwidth usage.
3. Filtering options with ability to ignore select traffic.

2.15 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

a. Network Controllers: 50 percent.

b. Programmable Application Controllers: Not less than 60 percent.
c. Application-Specific Controllers: Not less than 70percent.

2. Memory shall support DDC controller's operating system and database and shall include the following:

a. Monitoring and control.
b. Energy management, operation and optimization applications.
c. Alarm management.
d. Historical trend data of all connected I/O points.
e. Maintenance applications.
f. Operator interfaces.
g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Three.
4) BOs: Three.

2. Programmable Application Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Three.
4) BOs: Three.

3. Application-Specific Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: One.
2) AOs: One.
3) BIs: One.
4) BOs: One >.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.

4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

    a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
    b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
    c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
    d. Signal conditioning including transient rejection shall be provided for each AI.
    e. Capable of being individually calibrated for zero and span.
    f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

    a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
    b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
    c. Capable of being individually calibrated for zero and span.
    d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

    a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
    b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
    c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
    d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
    e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs shall be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings. Control algorithms shall operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.16 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.17 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.18 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.19 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30-character point name and up to 16 -character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:

1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:

    a. Reset air-handling unit supply temperature set points.
    b. Reset space temperature set points.
    c. De-energize equipment based on priority.

4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:

    a. Addition and deletion of loads controlled.
    b. Changes in demand intervals.
    c. Changes in demand limit for meter(s).
    d. Maximum shutoff time for equipment.
    e. Minimum shutoff time for equipment.
    f. Select rotational or sequential shedding and restoring.
    g. Shed and restore priority.

7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:

    a. Total electric consumption.
    b. Peak demand.
    c. Date and time of peak demand.
    d. Daily peak demand.

J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:

1. Support any of the following control loops, as applicable to control required:

    a. Two-position (on/off, open/close, slow/fast) control.
    b. Proportional control.
    c. Proportional plus integral (PI) control.
    d. Proportional plus integral plus derivative (PID) control.

        1) Include PID algorithms with direct or reverse action and anti-windup.

2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI [and BO]points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.20 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.

6. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1.
2. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
3. Construct enclosure of steel, not less than:

    a. Enclosure size less than 24 in.: 0.053 in. thick.
    b. Enclosure size 24 in. and larger: 0.067 in. thick.

4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

5. Hinged door full size of front face of enclosure and supported using:

    a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
    b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

6. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
    b. Size 24 in. and larger: Solid aluminum, 0.10 in. or steel, 0.093 in. thick.

7. Internal panel mounting hardware, grounding hardware and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
7. Construct enclosure of steel, not less than the following:

    a. Enclosure size less than 24 in.: 0.053 in. thick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches Tall: Two hinges.

b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
c. Sizes Larger 48 Inches Tall: Four hinges.

10. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
    b. Size 24 in. and larger: Solid aluminum, 0.10 in. or steel, 0.093 in. thick.

12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X SS:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Construct enclosure of Type 304 stainless steel, not less than the following:

    a. Size Less Than 24 Inches: 0.053 inch thick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

5. Outside body and door of enclosure with brushed No. 4 finish.
6. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 InchesTall: Two hinges.
    b. Sizes between 24 Inchesthrough 48 InchesTall: Three hinges.
    c. Sizes Larger 48 InchesTall: Four hinges.

7. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
8. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless-steel handle with integral locking mechanism.
9. Removable internal panel shall be 0.093-inch solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
10. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
11. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
12. Include enclosure with stainless-steel mounting brackets.

G. Freestanding, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.
4. Single-door enclosure sizes up to 84 inches tall by 36 inches wide.
5. Double-door enclosure sizes up to 84 inches tall by 72 inches wide.
6. Construct enclosure of steel, not less than 0.067 inch thick.
7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

8. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
9. Double-door enclosures with overlapping door design to include unobstructed full-width access.
10. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
11. Removable back covers.
12. Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
14. Grounding stud on enclosure body.
15. Thermoplastic pocket on inside of door for record Drawings and Product Data.
16. Nominal 4-inch-tall integral lifting base, not less than 0.123 inch thick, with predrilled holes for attachment to mounting surface.
17. Each top end of enclosure fitted with lifting tabs, not less than 0.172 inch thick.
18. Internal rack-mount shelves and angles as required by application.

H. Freestanding, NEMA 250, Types 4 and 12:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.
4. Type 12 Enclosure Sizes:

    a. Single-door enclosure sizes up to 90 inches tall by 36 inches wide.
    b. Double-door enclosure sizes up to 90 inches tall by 72 inches wide.

5. Type 4 Enclosure Sizes:

    a. Single-door enclosure sizes up to 72 inches tall by 36 inches wide.

6. Construct enclosure of steel, not less than 0.093 inch thick.
7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

8. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.

9. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty oil-tight handle with integral locking mechanism.
10. Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.
14. Top of enclosure fitted with no fewer than two lifting eyes.
15. Internal rack-mount shelves and angles as required by application.

I. Accessories:

1. Electric Heater:

   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from zero to 100 deg F.
   c. Capacity: 100, 200, 400, and 800 W as required by application.
   d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake and Exhaust Grilles:

   a. Number and size of fans, filters and grilles as required by application.
   b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
   c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
   d. Thermostatic control with adjustable set point from 32 to 140 deg F.
   e. Airflow Capacity at Zero Pressure:

      1) 4-Inch Fan: 100 cfm.
      2) 6-Inch Fan: 240 cfm.
      3) 10-Inch Fan: 560 cfm.

   f. Maximum operating temperature of 158 deg F.
   g. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
   h. 6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
   i. Dynamically balanced impellers molded from polycarbonate material.
   j. Fan furnished with power cord and polarized plug for power connection.
   k. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
   l. Removable Intake and Exhaust Grilles: ABS plastic or stainless steel of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
   m. Filters for NEMA 250, Type 1 Enclosures: Washable foam or aluminum, of a size to match intake grille.
   n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

3. Air Conditioner:

a. Electric-powered, self-contained air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.
b. Thermostatic control with adjustable set point from 60 to 120 deg F.
c. Enclosure side or top mounting with unit capacity as required by application.
d. Designed for closed-loop cooling with continuous operation in ambient environments up to 125 deg F.
e. HFC refrigerant.
f. Reusable and washable air filter.
g. High-performance, industrial-grade, and high-efficiency fans.
h. Furnished with power cord and polarized plug for power connection.
i. Condensate management system with base pan side drain.
j. Mounting hardware, gaskets, mounting template and instruction manual furnished with unit.
k. Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil and thermostat.

4. Thermoelectric Humidifier:

a. ABS plastic enclosure.
b. Capacity of 8 oz. of water per 24 hours.
c. Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.
d. Controlled to maintain enclosure relative humidity at an adjustable set point.
e. Unit power supply shall be internally wired to enclosure electrical power source.

5. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:

a. 0.25-inch-thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
c. Window kit shall be factory or shop installed before shipment to Project.

6. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:

a. 0.125-inch-thick, polycarbonate window mounted in enclosure door material.
b. Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.
c. Window kit shall be factory or shop installed before shipment to Project.

7. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:

a. 0.25-inch-thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
c. Window kit shall be factory or shop installed before shipment to Project.

8. Bar handle with keyed cylinder lock set.

2.21 RELAYS

A. General-Purpose Relays:

1.
2. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Relays shall have LED indication and a manual reset and push-to-test button.
8. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1.
2. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
3. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
4. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a dust-tight cover.
7. Include knob and dial scale for setting delay time.
8. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
    d. Repeatability: Within 2 percent.
    e. Recycle Time: 45 ms.
    f. Minimum Pulse Width Control: 50 ms.
    g. Power Consumption: 5 VA or less at 120-V ac.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.

10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1.
2. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either DPDT or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with a multibladed plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1.
2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.
6. Dropout current is adjustable from 50 to 95 percent of pickup current.
7. Include a current transformer, if required for application.
8. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:

1.
2. Description:

    a. On-off control and status indication in a single device.
    b. LED status indication of activated relay and current trigger.
    c. Closed-Open-Auto override switch located on the load side of the relay.

3. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F.
b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

4. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
b. Current Sensor Range: As required by application.
c. Current Set Point: Fixed or adjustable as required by application.
d. Current Sensor Output:

1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
3) Analog, zero- to 5- or 10-V dc.
4) Analog, 4 to 20 mA, loop powered.

5. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 1 enclosure.

2.22 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:

1. General Power-Line Conditioner Requirements:

a. Design to ensure maximum reliability, serviceability and performance.
b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

2. Standards: NRTL listed per UL 1012.
3. Performance:

a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.

2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h. Attenuate load-generated odd current harmonics 23 dB at the input.
i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
k. Common-mode noise attenuation of 140 dB.
l. Transverse-mode noise attenuation of 120 dB.
m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
n. Reliability of 200,000 hours' MTBF.
o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
p. Approximately 92 percent efficient at full load.

4. Transformer Construction:

a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
g. Include interface terminals for output power hot, neutral and ground conductors.
h. Label leads, wires and terminals to correspond with circuit wiring diagram.
i. Vacuum impregnate transformer with epoxy resin.

5. Cabinet Construction:

a. Design for panel or floor mounting.
b. NEMA 250, Type 1, general-purpose, indoor enclosure.

c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
d. Include a textured baked-on paint finish.

C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

1. The maximum continuous operating voltage shall be at least 125 percent.
2. The operating frequency range shall be 47 to 63 Hz.
3. Protection modes according to NEMA LS-1.
4. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:

    a. Line to Neutral: 45,000 A.
    b. Neutral to Ground: 45,000 A.
    c. Line to Ground: 45,000 A.
    d. Per Phase: 90,000 A.

5. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:

    a. Line to Neutral: 360 V.
    b. Line to Ground: 360 V.
    c. Neutral to Ground: 360 V.

6. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.

    a. Line to Neutral:

        1) 100 kHz: 42 dB.
        2) 1 MHz: 25 dB.
        3) 10 MHz: 21 dB.
        4) 100 MHz: 36 dB.

    b. Line to Ground:

        1) 100 kHz: 16 dB.
        2) 1 MHz: 55 dB.
        3) 10 MHz: 81 dB.
        4) 100 MHz: 80 dB.

7. Unit shall have LED status indicator that extinguishes to indicate a failure.
8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
9. Unit shall not generate any appreciable magnetic field.
10. Unit shall not generate an audible noise.

D. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.

3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

    a. Output voltage nominally 25-V dc within 5 percent.
    b. Output current up to 100 mA.
    c. Input voltage nominally 120-V ac, 60 Hz.
    d. Load regulation within 0.5 percent from zero- to 100-mA load.
    e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
    f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.23 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS

A. 250 through 1000 VA:

1.
2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

    a. Larger-capacity units shall be provided for systems with larger connected loads.
    b. UPS shall provide five minutes of battery power.

4. Performance:

    a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
    b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
    c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
    d. On Battery Output Voltage: Sine wave.
    e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
    f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
    g. Transfer Time: 6 ms.
    h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

5. UPS shall be automatic during fault or overload conditions.
6. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
7. Include front panel with power switch and visual indication of power, battery, fault and temperature.
8. Unit shall include an audible alarm of faults and front panel silence feature.
9. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
10. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
11. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
12. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:

1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

    a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
    b. UPS shall provide five minutes of battery power.

3. Performance:

    a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
    b. Power Factor: Minimum 0.97 at full load.
    c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
    d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
    e. Recharge time shall be a maximum of eight hours to 90 percent capacity.

4. UPS bypass shall be automatic during fault or overload conditions.
5. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
6. Batteries shall be sealed lead-acid type and be maintenance free.
7. Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

2.24 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 16 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in Section 260523 "Control-Voltage Electrical Power Cables."

    a. Cable shall be plenum rated.
    b. Cable shall have a unique color that is different from other cables used on Project.

2.25 RACEWAYS

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.26 ACCESSORIES

A. Pneumatic Pressure Gages:

1. Pressure gages shall a 1.5-inch-diameter face for pressures up through 30 psig and 2.5-inch-diameter face for greater pressures.
2. Include separate gages for branch pressure and main pressure lines.
3. White dial face with black printing.
4. Include 1-psig increment for scale ranges through 30 psig and 2-psig increment for larger ranges.
5. Accuracy: Within 1 percent of full-scale range.

B. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig.
3. Differential adjustable from 2 to 6 psig.
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

C. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.

3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

D. I/P and E/P Transducers:

1. Commercial Grade:

a.
b. The transducer shall convert an AO signal to a stepped pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig pneumatic signal for pneumatic actuation.
c. Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.
d. Transducer shall have auto/manual output switch, manual output control and an output pressure gage.
e. Accuracy: Within 1.0 percent of the output span.
f. Linearity: Within 0.5 percent of the output span.
g. Output Capacity: Not less than 550 scim at 15 psig.
h. Transducer shall have separate zero and span calibration adjustments.
i. The transducer shall withstand up to 40 psig of supply pressure without damage.
j. For use on only modulating pneumatic outputs that are associated with terminal units, including fan-coil units, VAV units, unit heaters and <Insert equipment>.

2. Industrial Grade:

a.
b. The transducer shall convert an AO signal to a proportional pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig pneumatic signal for pneumatic actuation. A stepped pneumatic signal is unacceptable.
c. Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.
d. Suitable for operation in an ambient temperature range of minus 40 to 150 deg F.
e. Accuracy: Within 0.5 percent of the output span.
f. Linearity: Within 0.5 percent of the output span.
g. Output Capacity: Not less than 5 scfm.
h. Transducer shall have zero and span calibration adjustments.
i. The transducer shall withstand up to 50 psig of supply pressure without damage.
j. For use on all modulating pneumatic outputs, not requiring a commercial-grade transducer.

E. E/P Switch:

1. Construct the body of cast aluminum or brass; three pipe body (common, normally open, and normally closed).
2. Internal construction of steel, copper or brass.
3. Air Connections: Barb.
4. Rating of 30 psig when installed in systems below 25 psig and of 150 psig when installed in systems above 25 psig.
5. Include coil transient suppression.

F. Instrument Enclosures:

1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than [12 inches] <Insert dimension> shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

G. Manual Valves:

1. Needle Type:

a. PTFE packing.
b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
c. Aluminum T-bar handle.
d. Include tubing connections.

2. Ball Type:

a. Body: Bronze ASTM B 62 or ASTM B 61.
b. Ball: Type 316 stainless steel.
c. Stem: Type 316 stainless steel.
d. Seats: Reinforced PTFE.
e. Packing Ring: Reinforced PTFE.
f. Lever: Stainless steel with a vinyl grip.
g. 600 WOG.
h. Threaded end connections.

2.27 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label bearing unique identification.

a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be as follows:

a. Operator Workstations: Minimum of 0.5 inch high.
b. Servers: Minimum of 0.5 inch high.

c. Printers: Minimum of 0.5 inch high.
d. DDC Controllers: Minimum of 0.5 inch high.
e. Gateways: Minimum of 0.5 inch high.
f. Repeaters: Minimum of 0.5 inch high.
g. Enclosures: Minimum of 0.5 inch high.
h. Electrical Power Devices: Minimum of 0.25 inch high.
i. UPS units: Minimum of 0.5 inch high.
j. Accessories: Minimum of 0.25 inch high.
k. Instruments: Minimum of 0.25 inch high.
l. Control Damper and Valve Actuators: Minimum of 0.25 inch> high.

3. Legend shall consist of white lettering on black background.
4. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

D. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

2.28 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate the following according to industry standards for each product, and to verify DDC system reliability specified in performance requirements:

1. DDC controllers.
2. Gateways.
3. Routers.
4. Operator workstations.

B. Product(s) and material(s) will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
2. Equipment to Be Connected: Refer to Contract Drawings

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:
    a. Lighting controls specified in Section 260926 "Lighting Control Panelboards."
    b. Fire-alarm system specified in Section 284621.11 "Addressable Fire-Alarm Systems."
    c. Access controls specified in Section 281300 "Access Control System Software and Database Management."

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
3. Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."

C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control valves, which are specified in Section 230923.11 "Control Valves."
2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
4. Tank-mounted sensors, switches and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
5. Pipe- and tank-mounted thermowells. Liquid thermowells are specified in Section 230923.27 "Temperature Instruments."

3.4 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer.

1. Programmable application or application-specific controller.
2. Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."
3. Unit-mounted airflow sensors, switches and transmitters, which are specified in Section 230923.14 "Flow Instruments."
4. Unit-mounted gas sensors and transmitters, which are specified in Section 230923.16 "Gas Instruments."

5. Unit-mounted leak-detection switches, which are specified in Section 230923.18 "Leak-Detection Instruments."
6. Unit-mounted speed sensors, switches and transmitters, which are specified in Section 230923.24 "DDC Speed Instruments."
7. Unit-mounted pressure sensors, switches and transmitters, which are specified in Section 230923.23 "Pressure Instruments."
8. Unit-mounted temperature sensors, switches and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
9. Relays.

B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.

1. Programmable application or application-specific controller.
2. Electric damper actuator. Dampers actuators are specified in Section 230923.12 "Control Dampers."
3. Unit-mounted flow and pressure sensors, transmitters and transducers. Flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
4. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
5. Relays.

C. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.

1. Programmable application or application-specific controller.
2. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
3. Flow and pressure switches. Air and liquid flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
4. Leak-detection switches, which are specified in Section 230923.18 "Leak-Detection Instruments."
5. Relays.

3.5 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

    a. Laboratory exhaust-air streams.
    b. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.6 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.

3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's[and ’Engineer's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Engineer's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.7 POT INSTALLATION

A. Install two portable operator terminal(s).

B. Turn over POTs to Owner at Substantial Completion.

C. Install software on each POT and verify that software functions properly.

3.8 SERVER INSTALLATION

A. Install one server at location directed by Owner.

B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed location in Shop Drawings.

C. Install software indicated on server(s) and verify that software functions properly.

D. Develop Project-specific graphics, trends, reports, logs, and historical database.

E. Power servers through dedicated UPS unit. Locate UPS adjacent to server.

3.9 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

B. Test gateway to verify that communication interface functions properly.

3.10 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

B. Test router to verify that communication interface functions properly.

3.11 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.12 INSTALLATION OF WIRELESS ROUTERS FOR OPERATOR INTERFACE

A. Install wireless routers to achieve optimum performance and best possible coverage.

B. Mount wireless routers in a protected location that is within 60 inches of floor and easily accessible by operators.

C. Connect wireless routers to field power supply and to UPS units if network controllers are powered through UPS units.

D. Install wireless router with latest version of applicable software and configure wireless router with WPA2 security and password protection. Create access password with not less than 12 characters consisting of letters and numbers and at least one special character. Document password in operations and maintenance manuals for reference by operators.

E. Test and adjust wireless routers for proper operation with portable workstation and other wireless devices intended for use by operators.

3.13 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, [Type 1] <Insert type> Enclosures: Use [painted steel] [galvanized-steel] [corrosion-resistant-coated steel] strut and hardware.
2. For NEMA 250, [Type 4] [Type 4X] <Insert type> Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures.

D. Install floor-mounted enclosures located on concrete housekeeping pads. Attach enclosure legs using stainless-steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.14 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.15 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install self-adhesive labels with unique identification on face for each of the following:

1. Operator workstation.
2. Server.
3. Printer.
4. Gateway.
5. Router.
6. Protocol analyzer.
7. DDC controller.
8. Enclosure.
9. Electrical power device.
10. UPS unit.
11. Accessory.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control [damper] [and] [valve] actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.16 NETWORK INSTALLATION

A. Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus.:

1. Operator workstations.

2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

C. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

1. Gateways.
2. Gateways and network controllers or programmable application controllers.
3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.

D. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.17 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Every network device shall have an assigned and documented MAC address unique to its network.
b. Ethernet Networks: Document MAC address assigned at its creation.
c. ARCNET or MS/TP networks: Assign from 00 to 64.

2. Network Numbering:

a. Assign unique numbers to each new network.
b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.

b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field shall support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field shall support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."
2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to [Drawings] [or] [tables] indicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.18 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Terminate wiring in a junction box.

a. Clamp cable over jacket in junction box.
b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.19 OPTICAL FIBER CABLE SYSTEM INSTALLATION

A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."

B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.20 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.

3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.21 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
2. Verify that control dampers are installed correctly for flow direction.
3. Verify that proper blade alignment, either parallel or opposed, has been provided.
4. Verify that damper frame attachment is properly secured and sealed.
5. Verify that damper actuator and linkage attachment is secure.
6. Verify that actuator wiring is complete, enclosed and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that valve ball, disc or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.22 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.23 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.24 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.25 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.

9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

        1) Identify I/O points for future reference.
        2) Simulate abnormal conditions to demonstrate proper function of safety devices.
        3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:

    a. Re-check I/O points that required corrections during initial test.

b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

a. Re-check I/O points that required corrections during second test.
b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.

a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and [50] <Insert number> percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:

a. Reaction to COV and alarm conditions during HLC.
b. Ability to update DDC system database during HLC.

5. Passing test is contingent on the following:

a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
b. All alarms, both binary and analog, are reported and printed; none are lost.
c. Compliance with response times specified.

6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.26 DDC SYSTEM WIRELESS NETWORK VERIFICATION

A. DDC system Installer shall design wireless DDC system networks to comply with performance requirements indicated.

B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.

C. Testing and verification of all wireless devices shall include, but not be limited to, the following:

1. Speed.
2. Online status.
3. Signal strength.

3.27 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:

a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.

b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
f. Trends, summaries, logs and reports set-up for Project.
g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
i. Software's ability to edit control programs off-line.
j. Data entry to show Project-specific customizing capability including parameter changes.
k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
l. Execution of digital and analog commands in graphic mode.
m. Spreadsheet and curve plot software and its integration with database.
n. Online user guide and help functions.
o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
p. System speed of response compared to requirements indicated.
q. For Each Network and Programmable Application Controller:

    1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
    2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
    3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
    4) Electric Power: Ability to disconnect any controller safely from its power source.
    5) Wiring Labels: Match control drawings.
    6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
    7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

r. For Each Operator Workstation:

    1) I/O points lists agree with naming conventions.
    2) Graphics are complete.

3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

a) Display of network device status.
b) Display of BACnet Object Information.
c) Silencing devices transmitting erroneous data.
d) Time synchronization.
e) Remote device re-initialization.
f) Backup and restore network device programming and master database(s).
g) Configuration management of routers.

3.28 EXTENDED OPERATION TEST

A. Extended operation test is intended to simulate normal operation of DDC system by Owner.

B. Operate DDC system for an operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

C. Provide an operator familiar with DDC system installed to man an operator workstation during eight hours of each normal business day occurring during operating period.

D. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when it occurs.

E. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
2. Downtime is when any I/O point in DDC system is unable to fulfill its' required function.
3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.
4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.
5. Downtime shall be logged in hours to nearest 0.1 hour.
6. Power outages shall not count as downtime but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages shall count as downtime.

F. During operating period, log downtime and operational problems are encountered.

1. Identify source of problem.
2. Provide written description of corrective action taken.
3. Record duration of downtime.
4. Maintain log showing the following:

    a. Time of occurrence.
    b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
    c. Downtime for each failed I/O point.
    d. Running total of downtime and total time of I/O point after each problem has been restored.

5. Log shall be available to Owner for review at any time.

G. For DDC system to pass extended operation test, total downtime shall not exceed [1] [2] <Insert number> percent of total point-hours during operating period.

1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.

H. Evaluation of DDC system passing test shall be based on the following calculation:

1. Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent

downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

I. Prepare test and inspection reports.

3.29 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.30 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.31 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.32 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

a. Provide not less than five days of training total.

b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
c. Total days of training shall be broken into not more than two separate training classes.
d. Each training class shall be not less than one consecutive day(s).

END OF SECTION 230923

Section 232113
Hydronic Piping

HAf V 0 CP Eq Ef AL

0R0 f ELAVET T1 - GN Eq VS

AR Tra. ings and general provisions oDtOe - ontra9tR

0R2 SGNNAf U

AR Se9tion in9ludes pipe and Dtting materials and Mdining metOods Dor tOe Dollo. ingw

0R 5otC ater Oeating pipingR
2R - OlledC ater pipingR
3R - ondenserC ater pipingR
hR NaceupC ater pipingR
YR - ondensateCdrain pipingR
I R Blo. do. nCdrain pipingR
: R AirCvent pipingR
zR SaDetyCvalveCnlet and Coutlet pipingR

0R3 A- VFl q SGBNFVVALS

AR Hrodu9t Tataw4or ea9Otype oDtOe Dollo. ingw

0R Hlasti9 pipe and Dttings . itOsolvent 9ementR
2R f Vf H and f Vf 4 . itOadOesiveR
3R HressureCseal DttingsR
hR - Oemi9al treatmentR

BR TelegatedOTesign Submittalw

0R Tesign 9al9ulations and detailed Dabri9ation and assembly oDpipe an9Oors and alignment guides6 Oangers and supports Dor multiple pipes6e" pansion Mints and loops6and atta9Oments oDtOe same to tOe building stru9tureR
2R Lo9ations oDpipe an9Oors and alignment guides and e" pansion Mints and loopsR
3R Lo9ations oDand details Dor penetrations6 in9luding sleeves and sleeve seals Dor e" terior . alls6 Dloors6basement6and Dundation . allsR
hR Lo9ations oDand details Dor penetration and Drestopping Dor DreCand smoceCated . all and Dloor and 9eiling assembliesR

0Rn Fq 41 f NAVFl q AL SGBNFVVALS

AR - oordination Tra. ingswHiping layout6 dra. n to s9ale6 on . Cl9O tOe Dollo. ing items are sOo. n and 9oordinated . itOea9OotOer6using input Dom installers oDtOe items involvedw

0R Suspended 9eiling 9omponentsR
2R 1 tOer building servi9esR
3R Stru9tural membersR

BR x ualiD9ation Tataw4or FnstallerR

- R Q elding 9ertiD9atesR

TR 4ield , ualityC9ontrol reportsR

ER Q ater AnalysiswSubmit a 9opy oDtOe . ater analysis to illustrate . ater , uality available at HromM9t siteR

0RY x GALFVU ASSGf Aq - E

AR Fnstaller x ualiD9ationsw

0R Fnstallers oD HressureCSealed / ointsw Fnstallers sOall be 9ertiDed by pressureCseal Mdint manuDa9turer as Oaving been trained and , ualiDed to Mdin piping . itOpressureCseal pipe 9ouplings and DttingsR

BR Steel Support Q eldingwx ualiDy pro9edures and personnel a99ording to AQ S T0R7T0RN6 ; Stru9tural Q elding - ode CSteelR,

- R Hipe Q eldingwx ualiDy pro9edures and operators a99ording to ASNE Boiler and Hressure Wessel - odew Se9tion FBR

0R - omply . itOASNE B30R6; Building Servi9es Hiping6 Dor materials6produ9ts6and installationR
2R - ertiDy tOat ea9O . elder Oas passed AQ S , ualiD9ation tests Dor . elding pro9esses involved and tOat 9ertiD9ation is 9urrentR

HAf V 2 CHf 1 TG- VS

2R0 HEf 41 f NAq - E f Ex GFf ENEq VS

AR 5 ydroni9 piping 9omponents and installation sOall be 9apable oD. itOstanding tOe DOllo. ing minimum . orcing pressure and temperature unless otOer. ise indi9atedw

0R 5 otCQ ater 5 eating Hipingw02Y psigat 2kk deg 4
2R - OlledCQ ater Hipingw02Y psigat 2kk deg 4R
3R - ondenserCQ ater Hipingw02Y psigat 0Yk deg 4R
hR NaceupCQ ater Hipingwzk psig at 0Yk deg 4
YR - ondensateCTrain Hipingw0Yk deg 4
l R Blo. do. nCTrain Hipingw2kk deg 4
: R AirCVent Hipingw2kk deg 4
zR SaDetyCValveCFnlet and CTutlet HipingwE, ual to tOe pressure oDtOe piping system to . COit is atta9OedR

2R2 - 1 HHEf VGBE AqT 4FVVFqPS

AR Tra. nCVemper - opper VubingwASVN B zz6Vype L

BR Prooved6Ne9Oani9alC oint6QrougOtG opper 4ittingswASNE B0I R22R

0R NanuDa9turers C SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tOe Dollo. ing6or approved e, ualw
aR Wega
bR W9tauli9
2R ProovedCEnd - opper 4ittingswASVN B : Y9opper tube or ASVN B Yzh6bronZe 9astingR
3R ProovedCEndCVube - ouplingswf igid pattern unless otOer. ise indi9atedXgasceted DttingRTu9tileC iron Oousing . itO ceys mat9Ong pipe and Dtting grooves6prelubri9ated EHTN gascet rated Dor minimum 23k deg 4or use . itOOousing6and steel bolts and nutsR

- R - opper or BronZe HressureCSeal 4ittingsw

0R NanuDa9turers C SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tOe Dollo. ing6or approved e, ualw
aR Wega
bR W9tauli9
2R 5ousingw- opperR
3R 1 Ct ings and Hipe StopswEHTNR
hR VoolswNanuDa9turer's spe9ial toolsR
YR Ninimum 2kkQpsigorcingQpressure rating at 2Yk deg 4 WeriDy tOat Dttings in ;- opper6Ne9Oani9ally 4ormed Vee 1 ption; HaragrapOobelo. are available Dor pipe siZes re, uired Dor HroM49tR

TR - opper6Ne9Oani9ally 4ormed Vee 1 ptionw4or Dorming VCbran9Oon 9opper . ater tubeR

0R NanuDa9turers C SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tOe Dollo. ing6or approved e, ualw
aR Wega
bR W9tauli9

ER QrougOtG opper GnionswASNE B0I R22R

2R3 SVEEL HIPHE AqT 4FVVFqPS

AR Steel HipewASVN A Y37A Y3N6 bla9c steel . itO plain endsX. elded and seamless6 Prade B6 and . all tC9cness as indi9ated in ;Hiping Appli9ations; Arti9leR

BR - astGFon VCreaded 4ittingswASNE B0I RkX- lasses 02Y and 2Yk as indi9ated in ;Hiping Appli9ations; Arti9leR

- R NalleableGFon VCreaded 4ittingsw ASNE B0I R36 - lasses 0Yk and 3kk as indi9ated in ;Hiping Appli9ations; Arti9leR

TR NalleableGFon GnionswASNE B0I R3j X- lasses 0Yk6 2Yk6 and 3kk as indi9ated in ;Hiping Appli9ations; Arti9leR

ER - astCFron Hipe 4langes and 4langed 4ittingswASNE B0l R06 - lasses 2Y6 02Y6 and 2YkXraised ground Da9e6and bolt Cooles spot Da9ed as indi9ated in ;Hiping Appli9ations; Arti9leR

4R QrougCtCSteel 4ittingswASVN A 23h7A 23hN6. all tCl9cness to mat9OadMining pipeR

PR QrougCt - astCand 4orgedCSteel 4langes and 4langed 4ittingswASNE B0l RY6in9luding bolts6nuts6and gascets oDtCe Dollo. ing material group6end 9onne9tions6and Da9ingsw

0R Naterial Proupw0R0R
2R End - onne9tionswButt . eldingR
3R 4a9ingswf aised Da9eR

5R Prooved Ne9Cani9alCoint 4ittings and - ouplingsw

0R NanuDa9turers C SubMe9t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tCe Dollo. ing6or approved e, ualw
aR Wega
bR W9tauli9
2R / oint 4ittingsw ASVN A Y3l 6 Prade l YCnYCl2 du9tile ironX ASVN A h: 7A h: N6 Prade 32Y0k malleable ironX ASVN A Y37A Y3N6 Vype 46 E6 or S6 Prade B Dabri9ated steelX or ASVN A 0kl 7A 0kl N6 Prade B steel Dttings . itO grooves or sCoulders 9onstru9ted to a99ept grooveCend 9ouplingsX. itOnuts6bolts6lo9cing pin6lo9cing toggle6or lugs to se9ure grooved pipe and DttingsR
3R - ouplingsw Tu9tileC or malleableCron Cousing and EHTN or nitrile gascet oD 9entral 9avity pressureCesponsive designX. itOnuts6bolts6lo9cing pin6lo9cing toggle6or lugs to se9ure grooved pipe and DttingsR

FR Steel HressureCSeal 4ittingsw

0R NanuDa9turers C SubMe9t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tCe Dollo. ing6or approved e, ualw
aR Wega
bR W9tauli9
2R 5ousingwSteelR
3R 1 Ct ings and Hipe StopwEHTNR
hR VoolswNanuDa9turer's spe9ial toolR
YR Ninimum 3kkCpsigorcingCpressure rating at 23k deg 4 qonCeinDor9ed6 . elded6 inCbran9O 9onne9tions . eacen a main pipelineXreinDor9ement is ne9essary unless . all tCl9cness oDbotO mains and bran9Oes is suD9ient to sustain pressure re, uired in ;HerDorman9e f e, uirements; Arti9leR

/ R Steel Hipe qippleswASVN A : 336made oDsame materials and . all tCl9cnesses as pipe in . Cl9OtCey are installedR

2Rn / 1 FqFqP NAVEf FALS

AR HipeC4lange Pascet NaterialswSuitable Dor 9Oemi9al and tCermal 9onditions oDpiping system 9ontentsR

0R ASNE B0l R206 nonmetalli96 Dat6 asbestos Dee6 07zCn9Oa"imum tCl9cness unless otCer. ise indi9atedR

aR 4ullC4a9e Vypew4or DatCa9e6- lass 02Y69astCron and 9astCbronZe DangesR
bR q arro. C4a9e Vypew4or raisedCa9e6- lass 2Yk69astCron and steel DangesR

BR 4lange Bolts and q utswASNE B0zR2R69arbon steel6unless otCer. ise indi9atedR

- R Hlasti96 HipeC4lange Pascet6 Bolts6 and q utsw Vype and material re9ommended by piping system manuDa9turer unless otCer. ise indi9atedR

TR Solder 4iller NetalswASVN B 326leadCree alloysRFn9lude . aterCusCable Du" a99ording to ASVN B z03R

ER BraZing 4iller NetalswAQS AYRz7AYRzN6B- uH Series6 9opperCpCospCorus alloys Dor Mining 9opper . itO 9opperXor BAgC06silver alloy Dor Mining 9opper . itObronZe or steelR

4R Qelding 4iller Netalsw- omply . itO AQS T0kR02N7T0kR02 Dor . elding materials appropriate Dor . all tC9cness and 9Cemi9al analysis oDsteel pipe being . eldedR

PR Pascet NaterialwVC9cness6material6and type suitable Dor Duid to be Candled and . orcing temperatures and pressuresR

2RY TFELE- Vf F= 4FVVFqPS

AR Peneral f e, uirementswAssembly oD9opper alloy and Derrous materials . itO separating non9ondu9tive insulating materialRFn9lude end 9onne9tions 9ompatible . itOpipes to be MinedR

BR Tiele9tri9 Gnionsw

0R NanuDa9turersw SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tCe Dollo. ingw

aR - apitol NanuDa9turing - ompanyR
bR - entral Hlasti9s - ompanyR
9R Nat9oCq or9aR
dR Qatts f egulator - oR
eR Jurn Fndustries6LL- R

2R Tes9riptionw

aR StandardwASSE 0k: j R
bR Hressure f atingw02Y psig minimum at 0zk deg 4
9R End - onne9tionswSolderCMint 9opper alloy and tCreaded DerrousR

- R Tiele9tri9 4langesw

0R NanuDa9turersw SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tCe Dollo. ingw

aR - apitol NanuDa9turing - ompanyR
bR - entral Hlasti9s - ompanyR
9R Nat9oCq or9aR
dR Qatts f egulator - oR
eR Jurn Fndustries6LL- R

2R Tes9riptionw

aR StandardwASSE 0k: j R
bR 4a9toryCabri9ated6bolted69ompanionCange assemblyR
9R Hressure f atingw02Y psig minimum at 0zk deg 40Yk psig
dR End - onne9tionswSolderCint 9opper alloy and tOreaded DerrousXtOreaded solderCint 9opper alloy and tOreaded DerrousR

TR Tiele9tri9C4lange Fnsulating Kitsw

0R NanuDa9turersw SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tOe Dollo. ingw

aR - apitol NanuDa9turing - ompanyR
bR - entral Hlasti9s - ompanyR
9R Nat9oCq or9aR
dR Qatts f egulator - oR
eR Jurn Fndustries6LL- R

2R Tes9riptionw

aR q on9ondu9ting materials Dor Deld assembly oD9ompanion DangesR
bR Hressure f atingw0Yk psig
9R Pascetwq eoprene or pOenoli9R
dR Bolt SleeveswHOenoli9 or polyetOyleneR
eR QasOerswHOenoli9 . itOsteel ba9cing . asOersR

ER Tiele9tri9 q ipplesw

0R NanuDa9turersw SubM49t to 9omplian9e . itO re, uirements6 provide produ9ts by one oD tOe Dollo. ingw

aR - apitol NanuDa9turing - ompanyR
bR - entral Hlasti9s - ompanyR
9R Nat9oCq or9aR
dR Qatts f egulator - oR
eR Jurn Fndustries6LL- R

2R Tes9riptionw

aR StandardwFAHN1 HS I I R
bR Ele9troplated steel nipple69omplying . itOASVN 4 0YhYR
9R Hressure f atingw3kk psig 22Y deg 4
dR End - onne9tionswNale tOreaded or groovedR
eR LiningwFnert and non9orrosive6propyleneR

HAf V 3 CE8E- GVF1 q

3R0 HFHFq P AHHLF- AVF1 q S

AR f eDer to - ontra9t Tra. ingsR

3R2 HFHFq P Fq SVALLAVF1 q S

AR Tra. ing plans6s9Oematis6and diagrams indi9ate general lo9ation and arrangement oDpiping systemsR Finstall piping as indi9ated unless deviations to layout are approved on - oordination Tra. ingsR

BR Finstall piping in 9on9ealed lo9ations unless otOer. ise indi9ated and e"9ept in e, uipment rooms and servi9e areasR

- R Finstall piping indi9ated to be e"posed and piping in e, uipment rooms and servi9e areas at rigOt angles or parallel to building . allsRTiagonal runs are proObited unless spe9iD9ally indi9ated otOer. iseR

TR Finstall piping above a99essible 9eilings to allo. suDD9ient spa9e Dor 9eiling panel removalR

ER Finstall piping to permit valve servi9ingR

4R Finstall piping at indi9ated slopesR

PR Finstall piping Dree oDsags and bendsR

5R Finstall Dttings Dor 9Oanges in dire9tion and bran9O9onne9tionsR

FR Finstall piping to allo. appli9ation oDinsulationR

/R Sele9t system 9omponents . itOpressure rating e, ual to or greater tOan system operating pressureR

KR Finstall groups oDpipes parallel to ea9OotOer6spa9ed to permit applying insulation and servi9ing oDvalvesR

LR Finstall drains69onsisting oDa tee Dtting6qHS 37h ball valve6and sOort qHS 37h tOreaded nipple . itO9ap6 at lo. points in piping system mains and else. Oere as re, uired Dor system drainageR

NR Finstall piping at a uniDorm grade oDkF2 per9ent up. ard in dire9tion oDDo. R

qR f edu9e pipe siZes using e99entri9 redu9er Dtting installed . itOlevel side upR

1R Finstall bran9O9onne9tions to mains using me9Oani9ally Dormed tee Dttings in main pipe6. itOtOe bran9O 9onne9ted to tOe bottom oDtOe main pipeR4or upOeed risers69onne9t tOe bran9O to tOe top oDtOe main pipeR

HR Fnstall valves a99ording to Se9tion 23kY23R02 ;Ball Walves Dor 5WA- Hiping6 Se9tion 23kY23R03 ;ButterDy Walves Dor 5WA- Hiping6 Se9tion 23kY23R0h ;- Ce9c Walves Dor 5WA- Hiping6 and Se9tion 23kY23R0Y ;P ate Walves Dor 5WA- HipingR

x R Fnstall unions in piping6 q HS 2 and smaller6 adMv9ent to valves6 at Dnal 9onne9tions oDe, uipment6 and else. Cere as indi9atedR

f R Fnstall Danges in piping6 q HS 2C07Z and larger6 at Dnal 9onne9tions oDe, uipment and else. Cere as indi9atedR

SR Fnstall sCutoDDvalve immediately upstream oDea9Odiele9tri9 DttingR

VR - omply . itO re, uirements in Se9tion 23kY0I ;E"pansion 4ittings and Loops Dor 5WA- Hiping; Dor installation oDe"pansion loops6e"pansion Mints6an9Oors6and pipe alignment guidesR

GR Fnstall sleeves Dor piping penetrations oD. alls69eilings6and DoorsR- omply . itO re, uirements Dor sleeves spe9iDed in Se9tion 23kY0: ;Sleeves and Sleeve Seals Dor 5WA- HipingR

WR Fnstall sleeve seals Dor piping penetrations oD9on9rete . alls and slabsR- omply . itO re, uirements Dor sleeve seals spe9iDed in Se9tion 23kY0: ;Sleeves and Sleeve Seals Dor 5WA- HipingR

QR Fnstall es9ut9Oeons Dor piping penetrations oD. alls6 9eilings6 and DoorsR- omply . itO re, uirements Dor es9ut9Oeons spe9iDed in Se9tion 23kY0z ;Es9ut9Oeons Dor 5WA- HipingR

3R3 TFELE- Vf F= 4FVVFq P Fq SVALLAVF1 q

AR Fnstall diele9tri9 Dttings in piping at 9onne9tions oDdissimilar metal piping and tubingR

BR Tiele9tri9 4ittings Dor q HS 2and SmallerwGse diele9tri9 unionsR

- R Tiele9tri9 4ittings Dor q HS 2C07Z to q HS hwGse diele9tri9 DangesR

TR Tiele9tri9 4ittings Dor q HS I and LargerwGse diele9tri9 Dange citsR

3Rn 5AqPEf SAqT SGHH1f VS

AR - omply . itO re, uirements in Se9tion 23kY2j ;5angers and Supports Dor 5WA- Hiping and E, uipment; Dor Canger6support6and an9Oor devi9esR- omply . itOtOe DollO. ing re, uirements Dor ma"imum spa9ing oD supportsR

BR - omply . itO re, uirements in Se9tion 23kYhz ;Wibration and Seismi9 - ontrols Dor 5WA- ; Dor seismi9 restraintsR

- R Fnstall tOe DollO. ing pipe atta9Oments w

0R AdMstable steel 9levis Cangers Dor individual CoriZontal piping less tOan 2k DeetlongR
2R AdMstable roller Cangers and spring Cangers Dor individual CoriZontal piping 2k Deetor longerR
3R Hipe f ollerwNSS SHCYz6Vype hh Dor multiple CoriZontal piping 2k Deet or longer6supported on a trapeZeR

hR Spring Oangers to support verti9al runsR

YR Hrovide 9opperO9lad Oangers and supports Dor Oangers and supports in dire9t 9onta9t . itO 9opper pipeR

I R 1 n plasti9 pipe6 install pads or 9usOions on bearing surDa9es to prevent Oanger Drom s9rat9Oing pipeR

TR Fnstall Oangers Dor steel piping . itO tOe Dollo. ing ma"imum spa9ing and minimum rod siZesw

0R q HS 37hwN a"imum span6: DeetR

2R q HS 0wN a"imum span6: DeetR

3R q HS 0O07 2wN a"imum span6j DeetR

hR q HS 2wN a"imum span60k DeetR

YR q HS 2O07 2wN a"imum span600 DeetR

I R q HS 3 and LargerwN a"imum span602 DeetR

ER Fnstall Oangers Dor dra. nOtemper 9opper piping . itO tOe Dollo. ing ma"imum spa9ing and minimum rod siZesw

0R q HS 37hwN a"imum span6Y DeetXminimum rod siZe607h in9OR

2R q HS 0wN a"imum span6I DeetXminimum rod siZe607h in9OR

3R q HS 0O07hN a"imum span6: DeetXminimum rod siZe637z in9OR

hR q HS 0O07 2wN a"imum span6z DeetXminimum rod siZe637z in9OR

YR q HS 2wN a"imum span6z DeetXminimum rod siZe637z in9OR

I R q HS 2O07 2wN a"imum span6j DeetXminimum rod siZe637z in9OR

: R q HS 3 and LargerwN a"imum span60k DeetXminimum rod siZe637z in9OR

4R Support verti9al runs at rooD6 at ea9O Door6 and at 0kODoot intervals bet. een DoorsR

3RY HFHE / 1 Fq V - 1 q SVf G- VFI q

AR f eam ends oD pipes and tubes and remove burrsR Bevel plain ends oD steel pipeR

BR f emove s9ale6 slag6 dirt6 and debris Drom inside and outside oD pipe and Dttings beDore assemblyR

- R Soldered / ointsw Apply ASVN B z036 . aterODusOable Du"6 unless otOer. ise indi9ated6 to tube endR - onstru9t Mints a99ording to ASVN B z2z or - TA's ;- opper Vube 5 andbooc6; using leadODee solder alloy 9omplying . itO ASVN B 32R

TR BraZed / ointsw - onstru9t Mints a99ording to AQ S's ;BraZing 5 andbooc6; ;Hipe and Vube; - Oapter6 using 9opperOpOospOorus braZing Dller metal 9omplying . itO AQ S AYRz7AYRzN R

ER VOreaded / ointswVOread pipe . itO tapered pipe tOreads a99ording to ASN E B0R2kR0R - ut tOreads Dull and 9lean using sOarp diesR f eam tOreaded pipe ends to remove burrs and restore Dull FT R / oin pipe Dttings and valves as Dollo. sw

0R Apply appropriate tape or tOread 9ompound to e"ternal pipe tOreads unless dry seal tOreading is spe9iDedR

2R T amaged VOreadswT o not use pipe or pipe Dttings . itO tOreads tOat are 9orroded or damagedR T o not use pipe se9tions tOat Oave 9ra9ced or open . eldsR

4R Q elded / ointsw - onstru9t Mdints a99ording to AQ S T 0kR02N7T 0kR026 using , ualiDed pro9esses and . elding operators a99ording to ;x uality Assuran9e; Arti9leR

PR 4langed / ointswSele9t appropriate gascet material6 siZe6 type6 and tO9kness Dor servi9e appli9ationR Finstall gascet 9on9entri9ally positionedRGse suitable lubri9ants on bolt tOreadsR

5R Prooved / ointswAssemble Mdints . itO 9oupling and gascet6 lubri9ant6 and boltsR- ut or roll grooves in ends oDpipe based on pipe and 9oupling manuDa9turer's . ritten instru9tions Dor pipe . all tO9knessRGse groovedGend Dttings and rigid6groovedGendQpipe 9ouplingsR

FR Ne9Oani9ally 4ormed6 - opperCVubeC1 utlet / ointswGse manuDa9turerGe9ommended tool and pro9edure6 and braZed MdintsR

/R HressureCSealed / ointswGse manuDa9turerGe9ommended tool and pro9edureRLeave insertion marcs on pipe aDer assemblyR

3R VEf NFqAL Ex GFHNEqV - 1qqE- VF1qS

AR SiZes Dor supply and return piping 9onne9tions sOall be tOe same as or larger tOan e, uipment 9onne9tionsR

BR Finstall 9ontrol valves in a99essible lo9ations 9lose to 9onne9ted e, uipmentR

- R Finstall ports Dor pressure gages and tOermometers at 9oil inlet and outlet 9onne9tionsR- omply . itO re, uirements in Se9tion 23kY0j ;Neters and P ages Dor 5 WA- HipingR;

3R 4FELT x GALFVU - 1qVf 1L

AR Hrepare Oydroni9 piping a99ording to ASNE B30R and as Dollo. sw

0R Leave Mdints6in9luding . elds6uninsulated and e" posed Dor e" amination during testR
2R Hrovide temporary restraints Dor e" pansion Mdints tOat 9annot sustain rea9tions due to test pressureRFDtemporary restraints are impra9ti9al6isolate e" pansion Mdints Dom testingR
3R 4lusO Oydroni9 piping systems . itO 9lean . aterX tOen remove and 9lean or repla9e strainer s9reensR
hR Fsolate e, uipment Dom pipingRFDa valve is used to isolate e, uipment6its 9losure sOall be 9apable oDsealing against test pressure . itOout damage to valveRFinstall blinds in Danged Mdints to isolate e, uipmentR
YR Finstall saDety valve6set at a pressure no more tOan one0CCrd OgOer tOan test pressure6to prote9t against damage by e" panding li, uid or otOer sour9e oDoverpressure during testR

BR HerDorm tOe Dollo. ing tests on Oydroni9 pipingw

0R Gse ambient temperature . ater as a testing medium unless tOere is risc oDdamage due to DeeZingRAnotOer li, uid tOat is saDe Dor . orcers and 9ompatible . itOpiping may be usedR
2R Q Cle Dlling system6use vents installed at OgO points oDsystem to release airRGse drains installed at lo. points Dor 9omplete draining oDtest li, uidR
3R Fsolate e" pansion tancs and determine tOat Oydroni9 system is Dull oD. aterR
hR SubMe9t piping system to Oydrostati9 test pressure tOat is not less tOan 0RY times tOe system's . orcing pressureR Vest pressure sOall not e" 9eed ma" imum pressure Dor any

vessel6 pump6 valve6 or otCer 9omponent in system under testRWeriDy tCat stress due to pressure at bottom oDverti9al runs does not e" 9eed j k per9ent oDspe9iDed minimum yield strengtO or 0R times tCe ;SE; value in Appendi" A in ASNE B30R6;Building Servi9es HipingR;

YR ADer Oydrostati9 test pressure Cas been applied Dor at least 0k minutes6 e" amine piping6 Mints6 and 9onne9tions Dor leacageRE liminate leacs by tigCtening6 repairing6 or repla9ing 9omponents6 and repeat Oydrostati9 test until tCere are no leacsR

I R Hrepare . ritten report oDtestingR

- R HerDorm tCe Dollo. ing beDore operating tCe systemw

0R 1 pen manual valves DullyR

2R Fnspe9t pumps Dor proper rotationR

3R Set maceup pressureCedu9ing valves Dor re, uired system pressureR

hR Fnspe9t air vents at CigO points oDsystem and determine iDall are installed and operating Dreely (automati9 type)6 or bleed air 9ompletely (manual type)R

YR Set temperature 9ontrols so all 9oils are 9alling Dor Dull Do. R

I R Fnspe9t and set operating temperatures oDOydroni9 e, uipment6 su9O as boilers6 9Cillers6 9ooling to. ers6 to spe9iDed valuesR

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Section 232116
Hydronic Piping Specialties

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract.

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Condenser-water piping.
4. Makeup-water piping.
5. Condensate-drain piping.
6. Blowdown-drain piping.
7. Air-vent piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at 200 deg F.
3. Condenser-Water Piping: 150 psig at 150 deg F.
4. Makeup-Water Piping: 80 psig at 150 deg F.
5. Condensate-Drain Piping: 150 deg F.
6. Blowdown-Drain Piping: 200 deg F.
7. Air-Vent Piping: 200 deg F.
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

B. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. Armstrong Pumps
   b. Bell & Gossett
   c. Flow Design, Inc.
   d. TA Hydronics

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. Armstrong Pumps

b. Bell & Gossett
c. Flow Design, Inc.
d. TA Hydronics

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig (860 kPa).
11. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Automatic Flow-Control Valves:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. Flow Design, Inc.
   b. TA Hydronics

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig
9. Maximum Operating Temperature: 250 deg F

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. AMTROL, Inc.
   b. Armstrong Pumps
   c. Bell & Gossett
   d. Taco, Inc.

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/8 (DN 6).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. AMTROL, Inc.
   b. Armstrong Pumps
   c. Bell & Gossett
   d. Taco, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/4 (DN 8).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 240 deg F (116 deg C).

C. Bladder-Type Expansion Tanks:

1. Manufacturers
   a. AMTROL, Inc.
   b. Armstrong Pumps
   c. Bell & Gossett
   d. Taco, Inc.

2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. AMTROL, Inc.
   b. Armstrong Pumps
   c. Bell & Gossett
   d. Taco, Inc.

2. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

E. In-Line Air Separators:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. AMTROL, Inc.
   b. Armstrong Pumps
   c. Bell & Gossett
   d. Taco, Inc.

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig (1207 kPa).
4. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

F. Air Purgers:

1. Manufacturers - Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. AMTROL, Inc.
   b. Armstrong Pumps
   c. Bell & Gossett
   d. Taco, Inc.

2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig (1035 kPa).
4. Maximum Operating Temperature: 250 deg F (121 deg C).

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

C. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.

4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Expansion Fittings: Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

F. Install expansion tanks on the floor. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

Section 232123
Hydronic Pumps

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Close-coupled, end-suction centrifugal pumps.
2. Separately coupled, vertically mounted, double-suction centrifugal pumps.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) Aurora Pumps
2) Bell and Gossett
3) Paco Pumps
4) Taco Pumps

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Capacities and Characteristics: Refer to equipment schedules on plans.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: re-greaseable ball bearings.

E. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

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. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.2 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) Aurora Pumps
2) Bell and Gossett
3) Paco Pumps

4) Taco Pumps

B. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Capacities and Characteristics: Refer to equipment schedules on plans.

D. Pump Construction:

1. Casing: Vertically split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, Class 250 flanges. Casing supports shall allow removal and replacement of impeller without disconnecting piping.]
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPR elastomer bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Single speed, secured to mounting frame, with adjustable alignment.

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. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.

5. Drain plug.
6. Factory-fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 230500 Basic Mechanical Materials and Methods”
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install [check, shutoff, and throttling valves on discharge side of pumps.

F. Install Y-type strainer or suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.

7. Open discharge valve slowly.

3.6 DEMONSTRATION

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

END OF SECTION 232123

Section 232300
Refrigerant Piping

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b1 Solenoid valves1
U1 Fot\gas bypass valves1
d1 Yilter dryers1
e1 Strainers1
H1 TressureVregulating valves1

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61 Tiston, 5emovable polytetrahHuoroetOylene seat1
x1 Elosing Spring, Stainless steel1
J1 . anual Gpening Stem, Seal UapMplated\steel stemMand grapOite seal1
; 1 Pnd EonneUtions, SoU etMunionMtOreadedMor HHanged1
" 1 . al imum Gpening Tressure, 01x0 psig1
/ 1 j or' ing Tressure 5ating, x00 psig1
f 01 . al imum Gperating cemperature, 2; x deg Y1

- 1 ServiUe) alves,

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss lmU1
b1 Pmerson Elimate ceUOnologies1
U1 Feldon TroduUts4Fenry ceUOnologies1
d1 Tar' er F annihh Eorp1
e1 Taul . ueller Eompany1
H1 5eHigeration SalesMmU1

21 Body, Yorged brass DitObrass Uap inUuding ' ey end to remove Ubre1

31 Eore, 5emovable ballVtype UOeU valve DitOstainless\steel spring1
61 Seat, TolytetrahHuoroetOylene1
x1 Pnd EonneUtions, Eopper spring1
J1 j or' ing Tressure 5ating, x00 psig1

P1 Solenoid) alves, Eomply DitO AF5h; J0 and NL 62/ 4 listed and labeled by a Rational 5eUognqed cesting Laboratory 9R5cLQ1

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss lmU1
b1 Pmerson Elimate ceUOnologies1
U1 Feldon TroduUts4Fenry ceUOnologies1
d1 Tar' er F annihh Eorp1
e1 Taul . ueller Eompany1

21 Body and Bonnet, Tlated steel1

31 Solenoid cubeMTlungerMElosing SpringMand Seat GriHUe, Stainless steel1
61 Seat, TolytetrahHuoroetOylene1
x1 Pnd EonneUtions, cOreaded1
J1 PleUtriUal, . oldedMDatertigOt Ubil in RP. A 2x0 enUosure oHtype reWuired by loUation DitO fk2VnUO Ubnduit adapterMand 26 f f x 20" Vj aUUbil1
; 1 j or' ing Tressure 5ating, 600 psig1
" 1 . al imum Gperating cemperature, 260 deg Y1

Y1 SaHety 5elieH) alves, Eomply DitO20f 0 AS. P Boiler and Tressure) essel Eode4listed and labeled by an R5cL1

f1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Feldon TroduUts4Fenry ceUOnologies1
U1 Tar' er FanniHin Eorp1
d1 Taul . ueller Eompany1

21 Body and Bonnet, - uUtile iron and steelMDitOneoprene GVring seal1

31 TistonMElosing SpringMand Seat hnsert, Stainless steel1
61 Seat, TolytetraHluoroetOylene1
x1 Pnd EonneUtions, cOreaded1
J1 j or' ing Tressure 5ating, 600 psig1
;1 . al imum Gperating cemperature, 260 deg Y1

C1 cOermostatiUPl pansion) alves, Eomply DitOAF5h; x01

f1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Pmerson Elimate ceUOnologies1
U1 Feldon TroduUts4Fenry ceUOnologies1
d1 Taul . ueller Eompany1

21 BodyMBonnetMand Seal Eap, Yorged brass or steel1

31 - iapOragmMTistonMElosing SpringMand Seat hnsert, Stainless steel1
61 TaU ing and Cas' ets, RonVasbestos1
x1 Eapillary and Bulb, Eopper tubing Hilled DitOreHrigerant UOarge1
J1 SuUtion cemperature, Eompatible DitOeWuipment1
;1 SuperOeat, Eompatible DitOeWuipment1
"1 5everseVHloD option 9Hor Oeat\pump appliUationsQ1
/1 Pnd EonneUtions, SoU etMHlareMor tOreaded union1
f01 j or' ing Tressure 5ating, ;00 psig1

F1 FotVCas Bypass) alves, Eomply DitONL 62/ 4listed and labeled by an R5cL1

f1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Feldon TroduUts4Fenry ceUOnologies1
U1 Tar' er FanniHin Eorp1

21 BodyMBonnetMand Seal Eap, - uUtile iron or steel1

31 - iapOragmMTistonMElosing SpringMand Seat hnsert, Stainless steel1
61 TaU ing and Cas' ets, RonVasbestos1
x1 Solenoid cubeMTlungerMElosing SpringMand Seat GriHiUe, Stainless steel1

J1 Seat, TolytetrafHuoroetOylene1
; 1 PWualiqer, Eompatible DitOeWuipment1
" 1 PleUtriUal, . oldedMDatertigOt Ubil in RP. A 2x0 enUosure oHtype reWuired by loUation DitO f k2VnUO Ubnduit adapter and 26 f f x 20" Vj aUUbil1
/ 1 Pnd EonneUtions, SoU et1
f 01 Set Tressure1
f f 1 cOrottling 5ange, . al imum x psig1
f 21 j or' ing Tressure 5ating, x00 psig1
f 31 . al imum Gperating cemperature, 260 deg Y1

h1 StraigOt\Vcype Strainers,

f 1 . anuHaUturers, SubXeUt to UbmplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Feldon TroduUts4Fenry ceUOhnologies1
U1 Tar' er FannitHn Eorp1

21 Body, j elded steel DitOUbrrosionVresistant Ubating1

31 SUreen, f 00VmesOstainless steel1
61 Pnd EonneUtions, SoU et or HBare1
x1 j or' ing Tressure 5ating, x00 psig1
J1 . al imum Gperating cemperature, 2; x deg Y1

z1 AngleVcype Strainers,

f 1 . anuHaUturers, SubXeUt to UbmplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Feldon TroduUts4Fenry ceUOhnologies1
U1 Tar' er FannitHn Eorp1

21 Body, Yorged brass or Uast bronqe1

31 - rain Tlug, Brass OeI plug1
61 SUreen, f 00VmesOmonel1
x1 Pnd EonneUtions, SoU et or HBare1
J1 j or' ing Tressure 5ating, x00 psig1
; 1 . al imum Gperating cemperature, 2; x deg Y1

K1 . oisturekLiWuid hndiUators,

f 1 . anuHaUturers, SubXeUt to UbmplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Pmerson Elimate ceUOhnologies1
U1 Feldon TroduUts4Fenry ceUOhnologies1
d1 Tar' er FannitHn Eorp1

21 Body, Yorged brass1

31 j indoD, 5eplaUeableMUearMHused glass DindoD DitOindiUating element proteUted by Hilter sUreen1
61 HndiUator, Eolor Uoded to sCoD moisture Uontent in parts per million 9ppmC1
x1 . inimum . oisture HndiUator Sensitivity, HndiUate moisture above J0 ppm1
J1 Pnd EonneUtions, SoU et or Hiare1
; 1 j or' ing Tressure 5ating, x00 psig1
" 1 . al imum Gperating cemperature, 260 deg Y1

L1 5eplaUeable\Eore Yilter - ryers, Eomply DitOAF 5h; 301

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtCe HolloDing or approved eWual,

a1 - anHoss HnU1
b1 Pmerson Elimate ceUChnologies1
U1 F eldon TroduUts4F enry ceUChnologies1
d1 Tar' er F annieHn Eorp1

21 Body and Eover, Tainted\steel sCell DitO duUtile\Iron UoverMstainless\steel sUreDsMand neoprene gas' ets1

31 Yilter . edia, f 0 miUronMpleated DitOintegral end rings4stainless\steel support1
61 - esiUUant . edia, AUtivated alumina UCarUbal1
x1 - esigned Hor reverse HboD 9Hor Ceat\pump appliUationsC1
J1 Pnd EonneUtions, SoU et1
; 1 AUUess Torts, RTS f k6 UonneUtions at entering and leaving sides Hor pressure diHerential measurement1
" 1 . al imum Tressure Loss, Eompatible DitOeWuipment1
/ 1 5ated YloD, Eompatible DitOeWuipment1
f 01 j or' ing Tressure 5ating, x00 psig1
f f 1 . al imum Gperating cemperature, 260 deg Y1

. 1 Termanent Yilter - ryers, Eomply DitOAF 5h; 301

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtCe HolloDing or approved eWual,

a1 - anHoss HnU1
b1 Pmerson Elimate ceUChnologies1
U1 F eldon TroduUts4F enry ceUChnologies1
d1 Tar' er F annieHn Eorp1

21 Body and Eover, Tainted\steel sCell1

31 Yilter . edia, f 0 miUronMpleated DitOintegral end rings4stainless\steel support1
61 - esiUUant . edia, AUtivated alumina UCarUbal1
x1 - esigned Hor reverse HboD 9Hor Ceat\pump appliUationsC1
J1 Pnd EonneUtions, SoU et1
; 1 AUUess Torts, RTS f k6 UonneUtions at entering and leaving sides Hor pressure diHerential measurement1
" 1 . al imum Tressure Loss, Eompatible DitOeWuipment1
/ 1 5ated YloD, Eompatible DitOeWuipment1
f 01 j or' ing Tressure 5ating, x00 psig1
f f 1 . al imum Gperating cemperature, 260 deg Y1

R1 . uHHers,

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 - anHoss hnU1
b1 Pmerson Elimate ceUOnologies1
U1 Feldon TroduUts4Fenry ceUOnologies1

21 Body, j elded steel DitOUorrosionVesistant Uoating1

31 Pnd EonneUtions, SoU et or HHare1
61 j or' ing Tressure 5ating, x00 psig1
x1 . al imum Gperating cemperature, 2; x deg Y1

G1 5eUeivers, Eomply DitOAF5h6/ x1

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 Feldon TroduUts4Fenry ceUOnologies1

21 Eomply DitO20f 0 AS. P Boiler and Tressure) essel Eode4listed and labeled by an R5cL1
31 Eomply DitONL 20; 4listed and labeled by an R5cL1
61 Body, j elded steel DitOUorrosionVesistant Uoating1
x1 cappings, hnletMoutletMiWuid level indiUatorMand saHety relieHvalve1
J1 Pnd EonneUtions, SoU et or tOreaded1
; 1 j or' ing Tressure 5ating, x00 psig1
" 1 . al imum Gperating cemperature, 2; x deg Y1

T1 LiWuid AUUumulators, Eomply DitOAF5h6/ x1

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 Pmerson Elimate ceUOnologies1
b1 Feldon TroduUts4Fenry ceUOnologies1
U1 Tar' er FannihHn Eorp1

21 Body, j elded steel DitOUorrosionVesistant Uoating1

31 Pnd EonneUtions, SoU et or tOreaded1
61 j or' ing Tressure 5ating, x00 psig1
x1 . al imum Gperating cemperature, 2; x deg Y1

216 5PY5hCP5ARcS

A1 ASF5AP 36M5V60; E, - iHHuorometOanekTentaHHuoroetOanekfMMM2VcetraHHuoroetOane1

f 1 . anuHaUturers, SubXeUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtOe HolloDing or approved eWual,

a1 Ar' ema hnUl
b1 - uTont YluoroUCemiUals - iv1
Ul Cenetron 5 eHrigerants4F oneyDell hnternational hnUl
d1 . el iUCem Yluor hnUl

B1 ASF 5 AP 36M5 \6f 0A, TentaHluoroetCanek- iHluorometCane1

f 1 . anuHaUturers, SubXcUt to UomplianUe DitO reWuirementsMprovide produUts by one oHtCe HollоDing or approved eWual,

a1 Ar' ema hnUl
b1 - uTont YluoroUCemiUals - iv1
Ul Cenetron 5 eHrigerants4F oneyDell hnternational hnUl
d1 . el iUCem Yluor hnUl

TA5 c 3 VP8 PENchGR

3f) AL) P AR- STPEhALcw ATTLHEAchGRS

A1 hnstall diapOragm paU less paU edVangle valves in suUtion and disUCarge lines oHUompressor1

B1 hnstall serviUe valves Hor gage taps at inlet and outlet oHCotVgas bypass valves and strainers iHtCey are not an integral part oHvalves and strainers1

E1 hnstall a UCeU valve at tCe Uompressor disUCarge and a liWuid aUUumulator at tCe Uompressor suUtion UonneUtion1

- 1 PI Uept as otCerDise indiUatedMinstall diapOragm paU less paU edVangle valves on inlet and outlet side oHHilter dryers1

P1 hnstall a HullVsiqeMtOreeVvalve bypass around Hilter dryers1

Y1 hnstall solenoid valves upstream Hrom eaUCeI pansion valve and CotVgas bypass valve1hnstall solenoid valves in Coriqontal lines DitO Ubil at top1

C1 hnstall tCermostatiUeI pansion valves as Uose as possible to distributors on evaporators1

f 1 hnstall valve so diapOragm Uase is Darmer tCan bulb1
21 SeUure bulb to UleanMstraigCtMCoriqontal seUtion oHsuUtion line using tDo bulb straps1- o not mount bulb in a trap or at bottom oHtCe line1
31 HHeI ternal eWualiqer lines are reWuiredMma' e UonneUtion DCere it Dill reHleUt suUtionVine pressure at bulb loUation1

F1 hnstall saHety relieHvalves DCere reWuired by 20f 0 AS. P Boiler and Tressure) essel Eode1 Tipe saHetyVelieHV valve disUCarge line to outside aUUording to ASF 5 AP f x1

h1 hnstall moistureWiWuid indiUators in liWuid line at tCe inlet oHtCe tCermostatiUeI pansion valve or at tCe inlet oHtCe evaporator Ubil Uapillary tube1

z1 hnstall strainers upstream Hrom and adXaUent to tCe HollоDing unless tCey are HurnisCed as an integral assembly Hor tCe deviUe being proteUted,

f 1 Solenoid valves1
21 cOermostatiUel pansion valves1
31 Fot\Vgas bypass valves1
61 Eompressor1

K1 Install Hilter dryers in liWuid line betDeen Ubmpressor and tOermostatiUel pansion valveMand in tOe suUtion line at tOe Ubmpressor1

L1 Install reUeivers siqed to aUUbmmodate pump\VdoDn UOarge1

. 1 Install HIel ible UbnneUtors at Ubmpressors1

312 ThTHRC HRScALLAcHGR

A1 - raDing plansMsUOematiUsMand diagrams indiUate general loUation and arrangement oH piping systems4 indiUated loUations and arrangements Dere used to siqe pipe and UalUulate HriUtion lossMel pansionMpump siqingM and otOer design Ubnsiderations1 Install piping as indiUated unless deviations to layout are approved on SOop - raDings1

B1 Install reHrigerant piping aUUbrding to ASF 5 AP f x1

E1 Install piping in UbnUealed loUations unless otOerDise indiUated and el Uept in eWuipment rooms and serviUe areas1

- 1 Install piping indiUated to be el posed and piping in eWuipment rooms and serviUe areas at rigOt angles or parallel to building Dalls1 - iagonal runs are proOibited unless speUHiUally indiUated otOerDise1

P1 Install piping above aUUessible Ueilings to alloD suHHUent spaUe Hor Ueiling panel removal1

Y1 Install piping adXaUent to maUOnes to alloD serviUe and maintenanUe1

C1 Install piping Hree oHsags and bends1

F1 Install Hittings Hor UOanges in direUtion and branUO UbnneUtions1

H1 SeleUt system Ubmponents DitOpressure rating eWual to or greater tOan system operating pressure1

z1 5 eHer to SeUtion 230/ 23 7- ireUt - igital Eontrol 9- - EQSystem Hor F) AE7 and SeUtion 230/ / 31f f 7SeWuenUe oH Gperations Hor F) AE - - E7 Hor solenoid valve UbntrollersMUbntrol DiringMand seWuenUe oHoperation1

K1 Install piping as sOort and direUt as possibleMDitOa minimum number oHXointsMelboDsMand Hittings1

L1 Arrange piping to alloD inspeUtion and serviUe oH reHrigeration eWuipment1 Install valves and speUialties in aUUessible loUations to alloD Hor serviUe and inspeUtion1 Install aUUess doors or panels as speUHied in SeUtion 0" 3f f 3 7AUUess - oors and Yrames7 iHvalves or eWuipment reWuiring maintenanUe is UbnUealed beOnd HinisOed surHaUes1

. 1 Install reHrigerant piping in proteUtive Ubnduit DOere installed beloDground1

R1 Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

G1 Slope refrigerant piping as follows:

f. Install horizontal hot gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
6. Liquid lines may be installed level.

T1 j. When brazing or soldering, remove solenoid valve coils and sight glasses; also remove valve stems, seats, and packing, and all nonmetallic internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

(1 Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

5 1 Identify refrigerant piping and valves according to Section 230xx3 7, Identification for F) AE Piping and Equipment 17.

S1 Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230xf ; 7, Sleeves and Sleeve Seals for F) AE Piping 17.

c1 Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230xf ; 7, Sleeves and Sleeve Seals for F) AE Piping 17.

N1 Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230xf " 7, Escutcheons for F) AE Piping 17.

313 THTP zGHRc EGRSc5 NEcHGR

A1 Ream ends of pipes and tubes and remove burrs.

B1 Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E1 Yill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

- 1 Soldered joints, Construction, joints according to ASc. B " 2" or E- A:s 7, Copper cube Handbook' 17.

P1 Brazed joints, Construction, joints according to Aj S:s 7, Brazing Handbook' 7, Chapter 7, Pipe and cube 17.

f. Use cype BCuT 9, copper-phosphorus alloy for joining copper soft et fittings with copper pipe.
2. Use cype BAg 9, cadmium-free silver alloy for joining copper with bronze or steel.

316 FARCP5S AR- SNTTG5cS

A1 Eomply DitOreWuirements Hor pipe Cangers and supports speUHied in SeUtion 230x2/ 7F angers and Supports Hor F) AE Tiping and PWuipment17

B1 Install tOe HolloDing pipe attaUOments,

f 1 AdXustable steel Uevis Cangers Hor individual Coriqontal runs less tOan 20 Heet long1
21 5oller Cangers and spring Cangers Hor individual Coriqontal runs 20 Heet or longer1
31 Tipe 5oller, . SS STVx" Mcype 66 Hor multiple Coriqontal piping 20 Heet or longerMsupported on a trapeqe1
61 Spring Cangers to support vertiUal runs1
x1 EopperVUad Cangers and supports Hor Cangers and supports in direUt UontaUt DitOUopper pipe1

E1 Install Cangers Hor Uopper tubing DitOtOe HolloDing mal imum spaUng and minimum rod diameters,

f 1 RTS f k2, . al imum spanMJ0 inUOes4minimum rodMf k6 inUO1
21 RTS xk", . al imum spanMJ0 inUOes4minimum rodMf k6 inUO1
31 RTS f , . al imum spanM, 2 inUOes4minimum rodMf k6 inUO1
61 RTS f Vf k6, . al imum spanM/ J inUOes4minimum rodM3k" inUO1
x1 RTS f Vf k2, . al imum spanM/ J inUOes4minimum rodM3k" inUO1
J1 RTS 2, . al imum spanM/ J inUOes4minimum rodM3k" inUO1
; 1 RTS 2Vf k2, . al imum spanMf 0" inUOes4minimum rodM3k" inUO1
" 1 RTS 3, . al imum spanMf 0 Heet4minimum rodM3k" inUO1
/ 1 RTS 6, . al imum spanMf 2 Heet4minimum rodMf k2 inUO1

31x YHPL- (NALhcw EGRc5GL

A1 TerHorm tOe HolloDing tests and inspeUtions,

f 1 Eomply DitOAS. P B3f 1xMEOapter) h1
21 cest reHrigerant pipingMspeUialtiesMand reUeivers1hsolate UompressorMUondenserMevaporatorMand saHety deviUes Hrom test pressure iHtOey are not rated above tOe test pressure1
31 cest ClgOVand loD\pressure side piping oHeaUO system separately at not less tOan tOe pressures indiUated in 7TerHormanUe 5eWuirements7 ArtiUle1

a1 Yill system DitOnitrogen to tOe reWuired test pressure1
b1 System sOall maintain test pressure at tOe maniHold gage tOrougOout duration oHtest1
U1 cest Xoints and Hittings DitOeleUtroniU lea' deteUtor or by brusOing a small amount oHsoap and glyUerin solution over Xoints1
d1 5ema' e lea' ing Xoints using neD materialsMand retest until satisHaUtory results are aUOieved1

B1 Trepare test and inspeUtion reports1

31U SwScP. EFA5ChRC

A1 EOarge system using tOe HolloDing proUedures,

f 1 Install Lure in filter dryers after lea' test but before evaLuation1
21 PvaLuate entire refrigerant system DitO a vaLuum pump to x00 miLrometers1 IfHvaLuum Colds for f 2 CoursMsystem is ready for LCarging1
31 Brea' vaLuum DitO refrigerant gasMalloDing pressure to build up to 2 psig1
61 ECarge system DitO a neD filter\dryer Lure in LCarging line1

31; A- zNScIRC

A1 AdXust tCermostatiLel pansion valve to obtain proper evaporator superCeat1

B1 AdXust CigOVand loD\pressure sDitLO settings to avoid sCort LyLuing in response to fluLtuating suLtion pressure1

E1 AdXust set\point temperature oHair\Londitioning or LCilled\Dater Lontrollers to tCe system design temperature1

- 1 TerHorm tCe follloDing adXustments beHore operating tCe refrigeration systemMaLUording to manufaLturer:s Dritten instruLtions,

f 1 Gpen sCutoffHvalves in Londenser Dater LrLuit1
21) erify tCat Lompressor oil level is LorreLt1
31 Gpen Lompressor suLtion and disLCarge valves1
61 Gpen refrigerant valves el Lept bypass valves tCat are used for otCer purposes1
x1 ECeLU open Lompressor\motor alignment and verify lubriLation for motors and bearings1

P1 5 eplaLe Lure oH-replaLeable filter dryer after system Cas been adXusted and after design flDD rates and pressures are establisCed1

PR- GY SPEcIGR 232300

Section 232500
HVAC Water Treatment

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following HVAC water-treatment systems:

1. Manual and automatic chemical-feed equipment and controls.
2. Chemical treatment test equipment.
3. Chemicals.
4. HVAC makeup-water softeners.

1.3 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. RO: Reverse osmosis.

C. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. TSS controllers.
6. Biocide feeder timers.
7. Chemical solution tanks.
8. Injection pumps.
9. Ozone generators.
10. UV-irradiation units.
11. Chemical test equipment.
12. Chemical material safety data sheets.
13. Water softeners.
14. RO units.
15. Multimedia filters.
16. Self-cleaning strainers.

17. Replaceable bag- or cartridge-type filters.
18. Centrifugal separators.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems.

C. 1. Include plans, elevations, sections, and attachment details.

1. Include diagrams for power and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, water softeners and water filtration units and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating, chilled water and glycol cooling, shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

D. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within [7 to 8] <Insert range>.
2. Calcium Carbonate Hardness: Maintain a value within [100 to 300] <Insert range> ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within [100 to 300] <Insert range> ppm.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 5 gal.
2. Minimum Working Pressure: 175 psig.

2.3 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers; and oxidizing biocide test for open cooling systems.

B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two-station rack for closed-loop systems.

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

2.5 HVAC MAKEUP-WATER SOFTENER

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

1. 3M
2. CSI Water Treatment Systems
3. Marlo Incorporated
4. Parker Boiler
5. Pentair, Inc.

B. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

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

D. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

E. Mineral Tanks:

1. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Fabricate and label Fiber Reinforced Plastic filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3. Pressure Rating: 150 psig minimum.
4. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F.
5. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
6. Support Legs or Skirt: Constructed of structural steel, welded, or bonded to tank before testing and labeling.
7. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
8. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
9. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging polyethylene strainers; arranged for even-flow distribution through resin bed.

F. Controls: Automatic; factory mounted on mineral tanks and factory wired.

1. Adjustable duration of regeneration steps.
2. Push-button start and complete manual operation override.
3. Pointer on pilot-control valve shall indicate cycle of operation.
4. Means of manual operation of pilot-control valve if power fails.
5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

    a. Slow opening and closing, nonslam operation.
    b. Diaphragm guiding on full perimeter from fully open to fully closed.
    c. Isolated dissimilar metals within valve.
    d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
    e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
    f. Sampling cocks for soft water.

6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons and that automatically resets after regeneration to preset total in gallons for next service run. Include alternator to regenerate one mineral tank with the other in service.

G. Brine Tank: Combination measuring and wet-salt storing system.

1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch thick; or molded polyethylene a minimum of 3/8 inch thick.
2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
3. Size: Large enough for at least four regenerations at full salting.

H. Factory-Installed Accessories:

1. Piping, valves, tubing, and drains.
2. Sampling cocks.
3. Main-operating-valve position indicators.
4. Water meters.

I. Water Test Kit: Include in wall-mounting enclosure for water softener.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water-testing equipment on wall near water-chemical-application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating and glycol cooling, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

G. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:

1. Install makeup-water softener.
2. Install water meter in makeup-water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval when contacts close at water meter in makeup-water supply connection.

4. Install test equipment and furnish test-kit to Owner.
5. Install RO unit for makeup water.
6. Install TSS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TSS concentration.

7. Install inhibitor injection timer with injection pumps and solution tanks.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into main steam supply header.

3.3 WATER SOFTENER INSTALLATION

A. Install water softener equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water-testing sets on wall adjacent to water softeners.

3.4 CONNECTIONS

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

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

E. See Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

F. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.

2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to "Performance Requirements" Article for each required characteristic. Sample boiler water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for cooling, chilled-water piping and heating, hot-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232500

Section 232923
Variable-Frequency Motor Controllers

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. EMI: Electromagnetic interference.

D. LED: Light-emitting diode.

E. NC: Normally closed.

F. NO: Normally open.

G. OCPD: Overcurrent protective device.

H. PID: Control action, proportional plus integral plus derivative.

I. RFI: Radio-frequency interference.

J. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For each VFC, accessories, and components, from manufacturer.

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

D. Product Certificates: For each VFC from manufacturer.

E. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01700 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ABB, Inc.

B. Danfoss, Inc.

C. Yasakawa Electric America, Inc.

D. Or approved equal.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A UL 508C.

B. Application: variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. All VFDs must be equipped with bypass.

F. Input (460VAC) 480VAC +/- 10%, # phase, 48-63Hz.

G. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or higher; maximum voltage equals input voltage.

H. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.

10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 1 to 300 or better +0.5 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
16. Must have the option to operate multiple motors with single VFD, to start, accelerate and decelerate all motors simultaneously.

I. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

J. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

K. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 1000 seconds.
4. Deceleration: 0.1 to 1000 seconds.
5. Current Limit: 30 to minimum of 125 percent of maximum rating.

L. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
4. Under- and overvoltage trips.
5. Inverter overcurrent trips.
6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
7. Critical frequency rejection, with three selectable, adjustable deadbands.
8. Instantaneous line-to-line and line-to-ground overcurrent trips.
9. Loss-of-phase protection and to detect a phase imbalance.
10. Current sensors to detect and report phase loss to the motor.
11. Reverse-phase protection.
12. Short-circuit protection.
13. Motor-overtemperature fault.
14. No flow detection

M. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

N. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

O. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

P. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

Q. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

R. Integral Input Disconnecting Means and OCPD: UL 489, thermal magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. NC & NO alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

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

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 0- to 10-V dc and 4- to 20-mA dc.
b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the direct digital control system for HVAC or other control systems:

a. 0- to 10-V dc.
b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc and 4- to 20-mA dc), which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).

d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One

G. Interface with Direct Digital Control System for HVAC: Factory-installed hardware and software shall interface with Direct Digital Control system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:

a. Monitoring: On-off status.
b. Control: On-off operation.

2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with direct digital control system for HVAC to remotely control and monitor lighting from a direct digital control system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the direct digital control system for HVAC.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

C. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, NEMA-rated contactor.
2. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.

3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

    b. Solid-State Overload Relays:

        1) Switch or dial selectable for motor-running overload protection.
        2) Sensors in each phase.
        3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
        4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
        5) Analog communication module.

    c. NO isolated overload alarm contact.
    d. External overload, reset push button.

2.7 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.

1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

B. Damper control circuit with end-of-travel feedback capability.

C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

E. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

F. Remote digital operator kit.

G. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.8 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.9 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Covered.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.
4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Spare control-wiring terminal blocks; unwired.

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

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

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed.

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer and Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. VFCs will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-

down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer and Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

F. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

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

END OF SECTION 232923

Section 233113
Metal Ducts

c Af V 0 CP R1 Rf AL

0-0 f RLAVRH HGEN5 R1 VS

A- Hra. ings and general provisions oDtOe EontraTt-

0-2 SN5 5 Af U

A- SeTtion MTludesw

0- SingleC all reTtangular duTts and Dttings-
2- SingleC all round duTts and Dttings-
3- SOeet metal materials-
h- Sealants and gas, ets-
Y- : angers and supports-

B- f elated SeTtionsw

0- SeTtion 23I YF3 qVesting4 AdWsting4 and BalanTing Dor : 6 AEq Dor testing4 adWsting4 and balanTing rekuirements Dor metal duTts-
2- SeTtion 2333I I qAir HuTt ATTessoriesq Dor dampers4 soundCTontrol deviTes4 duTtC mounting aTTess doors and panels4 turning vanes4 and Dej ible duTts-

0-3 c Rf xGf 5 A1 ER f RJ NMR5 R1 VS

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0-h AEVMG1 SNB5 MVALS

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2- Sealants and gas, ets-

B- SOop Hra. ingsw

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00- LoTations Dor duTt aTTessories4inTluding dampers4turning vanes4and aTTess doors and panels-
02- : angers and supports4inTluding metOods Dor duTt and building attaTOment and vibration isolation-

E- HelegatedCHesign Submittalw

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H- AS: f ARXRS1 A EomplianTew AppliTable rekuirements in AS: f ARXRS1 A FI -04SeTtion) -h-h C q 6AE System EonstruTtion and Msulation-q

cAf V 2 Ccf GHNEVS

2-0 SMIPLRC ALL f REVA1 PNLAf HNEVS A1 H xMVMIPS

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E- Longitudinal Seamsw SeleTt seam types and DabriTate aTTording to S5 AE1 A(s q 6AE HuTt EonstruTtion Standards C5 etal and xlej ible4q xigure 2C24 qf eTtangular HuTtXLongitudinal Seams4qDor statiTCpressure Tlass4 appliTable sealing rekuirements4 materials involved4 duTtC support intervals4 and otOer provisions in S5 AE1 A(s q 6AE HuTt EonstruTtion Standards C 5 etal and xlej ible-q

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H- Vees and Lateralsw SeleTt types and DabriTate aTTording to S5 AE1 A(s q; 6AE HuTt EonstruTtion Standards C5 etal and xlej ible4q xigure 3CY4qFI Hegree Vees and Laterals4q and xigure 3C;4qEoniTal Vees4q Dor statiTCpressure Tlass4 appliTable sealing rekuirements4 materials involved4 duTtGsupport intervals4 and otOer provisions in S5 AE1 A(s q; 6AE HuTt EonstruTtion Standards C5 etal and xlej ible-q

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B- Palvani8ed SOeet Steelw Eomply . itO ASV5 A) Y3XA) Y35 -

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;- ServiTewMdoor or outdoor-
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2- RcH5 GCing to seal in TonTave bead in Toupling or Dtting spigot-
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E- HuTt AttaTOmentsw SOeet metal sTre. s4blind rivets4or selDDapping metal sTre. s' Tompatible . itOduTt materials-

H- Vrape8e and f iser Supportsw

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cAf V3 CRz RENVMG1

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E- Mstall round duTts in maj imum praTtiTal lengtOs-

H- Mstall duTts . itODe. est possible WMnts-

R- Mstall DaTtoryCor sOopCabriTated Dttings Dor TOanges in direTtion4si8e4and sOape and Dor branTOTonneTtions-

x- Nnless otOer. ise indiTated4install duTts vertiTally and Cori8ontally4and parallel and perpendiTular to building lines-

P- Mstall duTts Tlose to . alls4overOead TonstruTtion4Tolumns4and otOer struTtural and permanent enTlosure elements oDbuilding-

: - Mstall duTts . itOa TlearanTe oD0 inTO4plus allo. anTe Dor insulation tOT, ness-

M- f oute duTts to avoid passing tOrougO transDormer vaults and eleTtriTal ekuipment rooms and enTlosures-

"- / Oere duTts pass tOrougO nonCDreCated interior partitions and ej terior . alls are ej posed to vie. 4 Tover tOe opening bet. een tOe partition and duTt or duTt insulation . itO sOeet metal Danges oDsame metal tOiT, ness as tOe duTt- Gverlap openings on Dour sides by at least 0CDX2 inTOes-

K- / Oere duTts pass tOrougO DreCated interior partitions and ej terior . alls4 install Dre dampers- Eomply . itO rekuirements in SeTtion 2333I I qAir HuTt ATTessoriesq Dor Dre and smo, e dampers-

L- c roteTt duTt interiors Dom moisture4 TonstruTtion debris and dust4 and otOer Doreign materials- Eomply . itO S5 AE1 A(s qMJ Puidelines Dor GTTupied Buildings Nnder EonstruTtion4q Appendij P4q HuTt Eleanliness Dor 1e. EonstruTtion Puidelines-q

3-2 HNEV SRALM1P

A- Seal duTts Dor duTt statiTQressure4 seal Tlasses4 and lea, age Tlasses speTiDed in q HuTt STOeduleq ArtiTle aTTording to S5 AE1 A(s q 6AE HuTt EonstruTtion Standards C5 etal and xlej ible-q

B- Seal duTts to tOe Dollo. ing seal Tlasses aTTording to S5 AE1 A(s q 6AE HuTt EonstruTtion Standards C5 etal and xlej ibleqw

0- Eomply . itO S5 AE1 A(s q 6AE HuTt EonstruTtion Standards C5 etal and xlej ible-q
2- NnTonditioned SpaTe4 SupplyCAir HuTts in c ressure Elasses 20MTO . g and Lo. erw Seal Elass B-
3- NnTonditioned SpaTe4 SupplyCAir HuTts in c ressure Elasses : igOer VOan 20MTO . gw Seal Elass A-
h- NnTonditioned SpaTe4 RjOaust HuTtsw Seal Elass E-
Y- NnTonditioned SpaTe4 f eturnCAir HuTtsw Seal Elass B-
)- Eonditioned SpaTe4 SupplyCAir HuTts in c ressure Elasses 20MTO . g and Lo. erw Seal Elass E-
7- Eonditioned SpaTe4 SupplyCAir HuTts in c ressure Elasses : igOer VOan 20MTO . gw Seal Elass B-
;- Eonditioned SpaTe4 RjOaust HuTtsw Seal Elass B-
F- Eonditioned SpaTe4 f eturnCAir HuTtsw Seal Elass E-

3-3 : A1 PRf A1 H SNcc Gf V M1 SVALLAVMG1

A- Eomply . itO S5 AE1 A(s q 6AE HuTt EonstruTtion Standards C5 etal and xlej ible4q EOapter Y4 q angers and Supports-q

B- Building AttaTOmentsw EonTrete inserts4 po. derCaTtuated Dasteners4 or struTturalCsteel Dasteners appropriate Dor TonstruTtion materials to . OiTOOangers are being attaTOed-

0- / Oere praTtiTal4 install TonTrete inserts beDore plaTing TonTrete-
2- Mstall po. derCaTtuated TonTrete Dasteners aDter TonTrete is plaTed and Tompletely Tured-
3- Nse po. derCaTtuated TonTrete Dasteners Dor standardC eigOt aggregate TonTretes or Dor slabs more tOan h inTOes tOiT, -

h- Ho not use po. derCaTtuated TonTrete Dasteners Dor ligCt. eigCtCaggregate TonTretes or Dor slabs less tCan h inTCes tCT, -

Y- Ho not use po. derCaTtuated TonTrete Dasteners Dor seismiT restraints-

E- : anger SpaTingw Eomply . itO S5 AE1 A(s q; 6AE HuTt EonstruTtion Standards C5 etal and xlej ible4q Vable YC04 qf eTtangular HuTt : angers 5 inimum Si8e4q and Vable YC24 q5 inimum : anger Si8es Dor f ound HuTt4q Dor maj imum Canger spaTing' install Cangers and supports . itCin 2h inTCes oDeaTOelbo. and . itCin h; inTCes oDeaTObranTOinterseTtion-

H- : angers Rj posed to 6ie. wVCreaded rod and angle or TCannel supports-

R- Support vertiTal duTts . itO steel angles or TCannel seTured to tCe sides oDtCe duTt . itO . elds4 bolts4sCeet metal sTre. s4or blind rivets' support at eaTODoor and at a maj imum intervals oD0) Deet-

x- Mstall upper attaTCments to struTtures- SeleTt and si8e upper attaTCments . itO pullCout4 tension4 and sCear TapaTities appropriate Dor supported loads and building materials . Cere used-

3-h EG1 1 REVMG1 S

A- 5 a, e TonneTtions to ekuipment . itO Dej ible TonneTtors Tomplying . itO SeTtion 2333I I qAir HuTt ATTessories-q

B- Eomply . itO S5 AE1 A(s q; 6AE HuTt EonstruTtion Standards C5 etal and xlej ibleq Dor branTO4 outlet and inlet4and terminal unit TonneTtions-

3-Y cAM1 VM1 P

A- caint interior oDmetal duTts tCat are visible tCrougO registers and grilles and tCat do not Cave duTt liner- Apply one Toat oDDat4blaT, 4latej paint over a Tompatible galvani8edCsteel primer-

3-) xMRLH J NALMWU EG1 Vf GL

A- cerDorm tests and inspeTtions-

B- Lea, age Vestsw

0- Eomply . itO S5 AE1 A(s q; 6AE Air HuTt Lea, age Vest 5 anual-q Submit a test report Dor eaTO test-

2- Vest tCe Dollo. ing systemsw

a- Supply HuTts . itO a c ressure Elass oD20MTO . g or : igCerw Vest representative duTt seTtions4seleTted by Rngineer Dom seTtions installed4 totaling no less tCan Yl perTent oDtotal installed duTt area Dor eaTO designated pressure Tlass-

b- f eturn HuTts . itO a c ressure Elass oD20MTO . g or : igCerw Vest representative duTt seTtions4seleTted by Rngineer Dom seTtions installed4 totaling no less tCan Yl perTent oDtotal installed duTt area Dor eaTO designated pressure Tlass-

T- Rj Caust HuTts . itO a c ressure Elass oD20MTO . g or : igCerw Vest representative duTt seTtions4seleTted by Rngineer Dom seTtions installed4 totaling no less tCan Yl perTent oDtotal installed duTt area Dor eaTO designated pressure Tlass-

3- Hisassemble4 reassemble4 and seal segments oD systems to aTTommodate lea, age testing and Dor TomplianTe . itO test rekuirements-
h- Vest Dor lea, s beDore applying ej ternal insulation-
Y- EonduTt tests at statiT pressures ekual to maj imum design pressure oD system or seTtion being tested- MD statiTC pressure Tlasses are not indiTated4 test system at maj imum system design pressure- Ho not pressuri8e systems above maj imum design operating pressure-
) - P ive seven days(advanTe notiTe Dor testing-

E- HuTt System Eleanliness Vestsw

0- 6 isually inspeTt duTt system to ensure tOat no visible Tontaminants are present-
2- Vest seTtions oD metal duTt system4 TOosen randomly by G. ner4 Dor Tleanliness aTTording to q6 aTuum Vestq in 1 AHEA AEf 4 qAssessment4 Eleaning and f estoration oD : 6 AE Systems-q

a- ATTeptable Eleanliness Levelw 1 et . eigOt oD debris TolleTted on tOe Dlter media sOall not ej Teed I -7Y mgXI I sk- Tm-

H- HuTt system . ill be Tonsidered deDeTtive iDit does not pass tests and inspeTtions-

R- c repare test and inspeTtion reports-

3-7 HNEV ELRA1 MI P

A- Elean ne. duTt system9 sC beDore testing4 adWsting4 and balanTing-

B- Nse serviTe openings Dor entry and inspeTtion-

0- Ereate ne. openings and install aTTess panels appropriate Dor duTt statiTC pressure Tlass iDrekuired Dor Tleaning aTTess- c rovide insulated panels Dor insulated duTt- Eomply . itO SeTtion 2333I I qAir HuTt ATTessoriesq Dor aTTess panels and doors-
2- HisTonneTt and reTonneTt Dej ible duTts as needed Dor Tleaning and inspeTtion-
3- f emove and reinstall Teiling to gain aTTess during tOe Tleaning proTess-

E- c artiTulate EolleTtion and Gdor Eontrolw

0- / Oen venting vaTuuming system inside tOe building4 use : Rc A Dltration . itO FF-F7 perTent TolleTtion eDDTienTy Dor I -3OniTronGsi8e 9or larger Qpartiles-
2- / Oen venting vaTuuming system to outdoors4 use Dlter to TolleTt debris removed Drom : 6 AE system4 and loTate ej Oaust do. n. ind and a. ay Drom air inta, es and otOer points oD entry into building-

H- Elean tOe Dollo. ing Tomponents by removing surDaTe Tontaminants and depositsw

0- Air outlets and inlets 9registers4 grilles4 and diDDusersQ
2- Supply4 return4 and ej Oaust Dans inTluding Dan Oousings4 plenums 9ej Tept Teiling supply and return plenumsQ4 sTrolls4 blades or vanes4 sOaDs4 baDDes4 dampers4 and drive assemblies-
3- Eoils and related Tomponents-
h- f eturnGair duTts4 dampers4 aTtuators4 and turning vanes ej Tept in Teiling plenums and meTOaniTal ekuipment rooms-
Y- SupplyGair duTts4 dampers4 aTtuators4 and turning vanes-

) - HediTated ej Caust and ventilation Tomponents and ma, eup air systems-

R- 5 eTCaniTal Eleaning 5 etCodologyw

0- Elean metal duTt systems using meTCaniTal Tleaning metCods tCat ej traTt Tontaminants Dom . itCn duTt systems and remove Tontaminants Dom building-
2- Nse vaTuumCTolleTtion deviTes tCat are operated Tontinuously during Tleaning- EonneTt vaTuum deviTe to do. nstream end oDduTt seTtions so areas being Tleaned are under negative pressure-
3- Nse meTCaniTal agitation to dislodge debris adCered to interior duTt surDaTes . itCout damaging integrity oDmetal duTts4or duTt aTTessories-
h- Elean Toils and Toil drain pans aTTording to 1 AHEA 0FF2- Keep drain pan operational-f inse Toils . itO Tlean . ater to remove latent residues and Tleaning materials' Tomb and straigCten Dns-
Y- c rovide drainage and Tleanup Dor . asCCdo. n proTedures-
) - AntimiTrobial Agents and Eoatingsw Apply RcACegistered antimiTrobial agents iDDungus is present- Apply antimiTrobial agents aTTording to manuDaTturer(s . ritten instruTtions aDer removal oDsurDaTe deposits and debris-

3-; SVAf V Nc

A- Air BalanTew Eomply . itO rekuirements in SeTtion 23I YF3 qVesting4 AdWsting4 and BalanTing Dor : 6 AE-q

3-F HNEV SE: RHNLRw

A- See EontraTt Hra. ings

R1 H Gx SREVMG1 233003

Section 233300
Air Duct Accessories

VAPR T - GENEPAL

T.T PELARE6 6 Dwf h ENRS

A. 6raCings and general provisions oc t, e wontraWt0 inWuding General and Supplementary wonditions and 6ivision 3T SpeWiWation SeWtions0apply to t, is SeWtion.

T.2 Sf h h APU

A. SeWtion IWWudesY

1. BaWdrad: and pressure reliecdampers.
2. BarometriWreliecdampers.
3. h anual volume dampers.
4. wontrol dampers.
5. : ire dampers.
6. Smol e dampers.
7. wombination dire and smol e dampers.
8. Rurning vanes.
9. 6uWt-mounted aWWess doors.
10. : leFible WonneWtors.
11. 6uWt aWWessory , ardCare.

B. Pelated PeQuirementsY

1. SeWtion 211Q21 k4 (Aw Gravity (entilatorsk or rooc-mounted ventilator Waps.

T.1 AwRND N Sf Bh MRRALS

A. VroduWt 6ataY: or eaW type ocproduWt.

1. : or duWt silenWers0inWude pressure drop and dynamiWinsertion loss data. IWWude breal out noise WalWulations or , ig, transmission loss Wasings.

B. S, op 6raCingsY : or duWt aWWessories. IWWude plans0 elevations0 seWtions0 details and attaW ments to ot, er Corl .

1. 6etail duWt aWWessories cabriWation and installation in duWs and ot, er WonstruWtion. IWWude dimensions0Ceig, ts0loads0and reQuired WearanWes) and met, od oc dield assembly into duWsystems and ot, er WonstruWtion. IWWude t, e olloCingY

a. SpeWal dittings.
b. h anual volume damper installations.
W wontrol-damper installations.
d. : ire-damper0 smol e-damper0 Wombination dire- and smol e-damper0 Weiling0 and Worridor damper installations0inWuding sleeves) and duWt-mounted aWWess doors and remote damper operators.

e. 6uWseWurity bars.
c. j iring 6iagramsY: or poCer0signal0and Wontrol Ciring.

T.q MM: DPh ARNDNAL Sf Bh MRRALS

A. woordination 6raCingsYPedeWted Weiling plans0draCn to sWale0on C, iW Weiling-mounted aWWess panels and aWWess doors reQuired cor aWWess to duWaWWessories are s, oCn and Wordinated Cit, eaW ot, er0using input crom Mstallers oct, e items involved.

B. SourWe Quality-Wontrol reports.

T." wLDSEDf R Sf Bh MRRALS

A. Dperation and h aintenanWe 6ataY : or air duW aWWessories to inWude in operation and maintenanWe manuals.

T.z h AMRENANwE h AREPMAL Sf Bh MRRALS

A. : urnis, eFtra materials t, at matW produWts installed and t, at are paWaged Cit, proteWive Wovering cor storage and identiced Cit, labels desWibing Wontents.

1. : usible LinI sY: urnis, Quantity eQual to T3 perWent ocamount installed.

VAPR2 - VPD6f wRS

2.T ASSEh BLU 6ESwPMWRNDN

A. womply Cit, N: VA H3A0 kMstallation oc Air wonditioning and (entilating Systems0k and Cit, N: VA H3B0kMstallation ocj arm Air 4eating and Air wonditioning Systems.k

B. womply Cit, Sh AwNAZsk4 (Aw 6uWwonstruWion Standards - h etal and : leFiblekcor aWeptable materials0material t, iWnesses0and duWWonstruWion met, ods unless ot, erCise indiWated. S, eet metal materials s, all be cree ocpitting0seam marI s0roller marI s0stains0disWolorations0and ot, er imperCWions.

2.2 h AREPMALS

A. Galvani; ed S, eet SteelYwomply Cit, ASRh Az" 15Az" 1h .

1. Galvani; ed woating 6esignationYGH3.
2. EFposed-SurcaWe : inis, Yh ill p, osp, ati; ed.

B. Aluminum S, eetsY womply Cit, ASRh B23H0 Alloy 13310 Remper 4Tq) Cit, mill cinis, cor WonWealed duWs and standard0T-side brig, t cinis, cor eFposed duWs.

w. EFtruded AluminumYwomply Cit, ASRh B22T0Alloy z3z10Remper Rz.

6. PeinoorWement S, apes and VlatesYGalvani; ed-steel reinoorWement C, ere installed on galvani; ed s, eet metal duWts) Wompatible materials oor aluminum and stainless-steel duWts.

E. Rie PodsYGalvani; ed steel0T5q-inW, minimum diameter oor lengt, s 1z inW, es or less) 15X-inW, minimum diameter oor lengt, s longer t, an 1z inW, es.

2.1 BAwK6PA: RAN6 VPESSf PE PELMt: 6Ah VEPS

A. h anuoaWturers - SubxeW to WomplianWe Cit, reQuirements0 provide produWts by one oc t, e olloCing0or approved eQualY

1. Green, eW : an worporation
2. Nailor Mdustries
3. Vottorc
4. PusI in wompany

B. 6esWriptionYGravity balanWed.

w. h aFimum Air (eloWtyY2333 opm.

6. h aFimum System VressureY2-inW Cg.

E. : rameY4at-s, aped03.3"-inW t, iW0galvani; ed s, eet steel0Cit, Celded Worners or meW aniWally attaW ed and mounting dange.

:. BladesYh ultiple single-pieWe blades0Wenter pivoted0ooc-Wenter pivoted0or end pivoted0maFimum z-inW Cidt, 03.32"-inW -t, iW0roll-oormed aluminum Cit, sealed edges.

G. Blade AWtionYVarallel.

4. Blade SealsYNeoprene0meW aniWally loWed.

M Blade AFlesY

1. h aterialYStainless steel.
2. 6iameterY3.23 inW.

J. Rie Bars and BraWetsYAluminum.

K. Peturn SpringYAdxustable tension.

L. BearingsYSteel ball or synt, etiWpivot bus, ings.

h. AWessoriesY

1. Adxustment deviWe to permit setting oor varying dioerential statiWpressure.
2. wounterCeig, ts and spring-assist I its oor vertiWal airdoC installations.
3. EleWtriWaWtuators.
4. w, ain pulls.
5. SWeen h ountingY: ront mounted in sleeve.

a. Sleeve R, iWnessY23 gauge minimum.
b. Sleeve Lengt, Yz inW es minimum.

6. SWeen h ountingYPear mounted.
7. SWeen h aterialYGalvani; ed steel or Aluminum.
8. SWeen RypeYBird.
9. H3-degree stops.

2.q BAPDh ERPMw PELME: 6Ah VEPS

A. h anucaWturers - SubxeWt to WomplianWe Cit, reQuirements0 provide produWts by one oc t, e colloCing0or approved eQualY

1. Green, eW : an worporation
2. Nailor Mdustries
3. Vottorc
4. Pusl in wompany

B. Suitable cor , ori; ontal or vertiWal mounting.

w. h aFimum Air (eloWtyY2333 cpm.

6. h aFimum System VressureY2-inW Cg.

E. : rameY4 at-s, aped03.3" -inW t, iW0galvani; ed s, eet steel0Cit, Celded W0rners or meW aniWally attaW ed and mounting dange.

: . BladesY

1. h ultiple03.32" -inW -t, iW0roll-cormed aluminum.
2. h aFimum j idt, Yz inW es.
3. AWtionYVarallel.
4. BalanWeYGravity.
5. EWWentriWally pivoted0Doc-We nter pivoted0End pivoted.

G. Blade SealsYNeoprene.

4. Blade AFlesYStainless steel.

M Rie Bars and BraWetsY

1. h aterialYAluminum.
2. Pattle cree Cit, H3-degree stop.

J. Peturn SpringYAdxustable tension.

K. BearingsYSynt, etiW0Stainless steel0or Bron; e.

L. AWessoriesY

1. : lange on intal e.
2. Adxustment deviWe to permit setting cor varying dicerential statiWpressures.

2." h ANf AL (DLf h E 6Ah VEPS

A. Standard0Steel0h anual (olume 6ampersY

1. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0provide produWts by one oct, e colloCing0or approved eQualY

   a. Green, eW : an worporation
   b. Nailor Mdustries
   W Vottorc
   d. PusI in wompany

2. Standard leal age rating0Cit, linI age outside airstream.
3. Suitable cor , ori; ontal or vertiWal appliWations.
4. : rames0Y

   a. : rameY4 at-s, aped03.3Hq-inW-t, iW0galvani; ed s, eet steel.
   b. h itered and Celded Worners.
   W : langes cor attaW ing to Calls and dangeless crames cor installing in duWts.

5. BladesY

   a. h ultiple or single blade.
   b. Varallel- or opposed-blade design.
   W Stiocen damper blades cor stability.
   d. Galvani; ed-steel03.3zq inW t, iW.

6. Blade AFlesYStainless steel.
7. BearingsY

   a. Dil-impregnated bron; e0h olded synt, etiW0Dil-impregnated stainless-steel sleeve0 or Stainless-steel sleeve/.
   b. 6ampers in duWts Cit, pressure Wlasses oc 1-inW Cg or less s, all , ave aFles cull lengt, ocdamper blades and bearings at bot, ends ocoperating s, act.

8. Rie Bars and BraWetsYGalvani; ed steel.

B. Standard0Aluminum0h anual (olume 6ampersY

1. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0provide produWts by one oct, e colloCing0or approved eQualY

   a. Green, eW : an worporation
   b. Nailor Mdustries
   W Vottorc
   d. PusI in wompany

2.
3. Standard leal age rating0Cit, linI age outside airstream.
4. Suitable cor , ori; ontal or vertiWal appliWations.
5. : ramesY4 at-s, aped03.T3-inW-t, iW0aluminum s, eet W annels) crames Cit, danges cor attaW ing to Calls and dangeless crames cor installing in duWts.
6. BladesY

a. h ultiple or single blade.
b. Varallel- or opposed-blade design.
W Sticœen damper blades œor stability.
d. Poll-: ormed Aluminum BladesY3.T3-inW, -t, iW aluminum s, eet.
e. EFtruded-Aluminum BladesY3.3" 3-inW, -t, iW eFtruded aluminum.

7. Blade AFlesYStainless steel or Nonœrrous metal.
8. BearingsY

a. Dil-impregnated bron; e0h olded synt, etiW0Stainless-steel sleeve.
b. 6ampers in duWts Cit, pressure WIasses oc1-inW, Cg or less s, all , ave aFles œull lengt, ocdamper blades and bearings at bot, ends ocoperating s, act.

9. Rie Bars and BraWetsYAluminum.

2.z wDNRPDL 6Ah VEPS

A. h anuœaWturers - SubxeW to WomplianWe Cit, reQuirements0 provide produWts by one oc t, e œolloCing0or approved eQualY

1. Green, eW : an worporation
2. Nailor Mdustries
3. Vottorc
4. Pusl in wompany

B. LoC-leal age rating0Cit, linl age outside airstream0and bearing Ah wA7s wertiœed Patings Seal œor bot, air perœormanWe and air leal age.

w. : ramesY

1. 4at s, aped.
2. 3.3Hq-inW, -t, iW0galvani; ed s, eet steel or 3.3" -inW, -t, iW stainless steel.
3. h itered and Celded Worners.

6. BladesY

1. h ultiple blade Cit, maFimum blade Cidt, ocz inW, es.
2. Varallel- and opposed -blade design.
3. Galvani; ed-steel0Stainless steel0or Aluminum.
4. AirœoilA
5. Blade EdgingYwlosed-Well neoprene .
6. Blade EdgingYMdatable seal blade edging0or replaWeable rubber seals.

E. Blade AFlesYT2-inW, -diameter) stainless steel) blade-linl age , ardCare oc; inWplated steel and brass) ends sealed against blade bearings.

1. Dperating Remperature PangeY: rom minus q3 to plus 233 deg : .

: . BearingsY

1. Dil-impregnated bron; e0 h olded synt, etiW0 Dil-impregnated stainless-steel sleeve0 or Stainless-steel sleeve.

2. 6ampers in duWs Cit, pressure Wlasses oc1-inW Cg or less s, all , ave aFles oull lengt, oc damper blades and bearings at bot, ends ocoperating s, act.
3. R, rust bearings at eaW end ocevery blade.

2.Q : MPE 6Ah VEPS

A. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0provide produWs by one oc t, e coolloCing0or approved eQualY

1. Air BalanWe0MW
2. Green, eW : an worporation
3. Vottorc
4. PusI in wompany

B. Mbot, types oc dampers are reQuired in kRypek Varagrap, beloC0indiWate loWation oc eaW on 6raCings.

w. RypeYStatiWand dynamiWrated and labeled aWWording to f L """ by an NPRL.

6. wlosing rating in duWs up to q-inW Cg statiWpressure Wlass and minimum 2333-cpm veloWty.

E. : ire PatingYT-T52 , ours.

: . : rameYwurtain type Cit, blades outside airstream) cabriWated Cit, roll-cormed galvani; ed steel) Cit, mitered and interloWing Worners) gauge in aWWordanWe Cit, f L listing.

G. h ounting SleeveY: aWtory- or cield-installed0galvani; ed s, eet steel) gauge in aWWordanWe Cit, f L listing.

4. h ounting DrientationY(ertiWal or , ori; ontal as indiWated.

M BladesYPoll-cormed0interloWing0galvani; ed s, eet steel) gauge in aWWordanWe Cit, f L listing.

J. 4ori; ontal 6ampersYMWude blade loW and stainless-steel Wosure spring.

K. 4eat-Pesponsive 6eviWeYPeplaWeable0Tz" deg : rated0cusible linI s.

2.X wDh BMARND : MPE AN6 Sh DKE 6Ah VEPS

A. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0provide produWs by one oc t, e coolloCing0or approved eQualY

1. Air BalanWe0MW
2. Green, eW : an worporation
3. Vottorc
4. PusI in wompany

B. RypeY6ynamiWrated and labeled aWWording to f L """ and f L """S by an NPRL.

w. wlosing rating in duWs up to q-inW Cg statiWpressure Wlass and minimum 2333-cpm veloWty.

6. : ire PatingYT-T52 , ours.

E. : rameY4 at-s, aped0galvani; ed s, eet steel0Cit, Celded interloWing0gusseted or meWanisWally attaWed Worners and mounting dange) gauge in aWordanWe Cit, f L listing.

: . 4 eat-Pesponsive 6 eviWeYEleWtriWresettable deviWe and sCitW paWage0caWtory installed0rated.

G. SmoI e 6 eteWtorYMtegral0caWtory Cired cor single-point WonneWtion.

4 . BladesYPoll-cormed0, ori; ontal0interloWing0galvani; ed s, eet steel) gauge in aWordanWe Cit, f L listing.

M LeaI ageYwlass M

J. Pated pressure and veloWty to eFWeed design airdoC Wonditions.

K. h ounting SleeveY : aWtory-installed0 galvani; ed s, eet steel) lengt, to suit Call or door appliWation Cit, caWtory-curnis, ed siliWone WaulI ing) gauge in aWordanWe Cit, f L listing.

L. h aster Wontrol panel cor use in dynamiWsmoI e-management systems.

h . 6 amper h otorsYtCo-position aWion.

N. womply Cit, NEh A designation0temperature rating0serviWe caWtor0enWosure type0and ecoWenWy reQuirements cor motors speWied in SeWion 213" T1 kwommon h otor PeQuirements cor 4 (Aw EQuipment.k

1. h otor Si; esYh inimum si; e as indiWated. Mdnot indiWated0large enoug, so driven load Cill not reQuire motor to operate in serviWe caWtor range above T.3.
2. wontrollers0EleWtriWal 6 eviWes0and j iringYwomply Cit, reQuirements cor eleWtriWal deviWes and WonneWtions speWied in SeWion 213H21 k6 ireW 6 igital wontrol 866 w9 System cor 4 (Aw.k
3. Vermanent-Split-wapaWtor or S, aded-Vole h otorsYj it, oil-immersed and sealed gear trains.
4. Spring-Peturn h otorsYEQuip Cit, an integral spiral-spring meWanism C, ere indiWated. EnWose entire spring meWanism in a removable , ousing designed cor serviWe or adxustments. Si; e cor running torQue rating ocT" 3 in. F lbcand breaI aCay torQue rating oc T" 3 in. F lbc.
5. Dutdoor h otors and h otors in Dutdoor-Air MtaI esYEQuip Cit, D-ring gasI ets designed to maI e motors Ceat, erprooc EQuip motors Cit, internal , eaters to permit normal operation at minus q3 deg : .
6. Nonspring-Peturn h otorsY: or dampers larger t, an 2" sQ d.0si; e motor cor running torQue rating ocT" 3 in. F lbcand breaI aCay torQue rating oc133 in. F lbc.
7. EleWtriWal wonneWtionYTT" (0single p, ase0z3 4 ; .

D. AWessoriesY

1. AuFiliary sCitWes cor signaling0can Wontrol or position indiWation.
2. Rest and reset sCitWes0damper mounted.

2.H Rf PNMNG (ANES

A. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0 provide produWs by one oc t, e coIloCing0or approved eQuaIY

1. 6uro6yne Mdustries0MW
2. 6uWmate0MW

B. hanucaWured Running (anes cor hetal 6uWsYwurved blades ocgalvani;ed s,eet steel) support Cit, bars perpendiWular to blades set) set into vane runners suitable cor duW mounting.

1. AWoustiWRurning (anesY: abriWate aircoil-s,aped aluminum eFtrusions Cit, percorated caWes and cibrous-glass cill.

w. hanucaWured Running (anes cor Nonmetal 6uWsY: abriWate Wurved blades oc resin-bonded ciberglass Cit, aWyliWpolymer Woating) support Cit, bars perpendiWular to blades set) set into vane runners suitable cor duW mounting.

6. General PeQuirementsYwomply Cit, Sh AwNA73k4 (Aw 6uWwonstruWWon Standards - hetal and :leFiblek): igures q-10k(anes and (ane Punners0k and q-q0k(ane Support in ElboCs.k

E. (ane wonstruWWonY6ouble Call.

:. (ane wonstruWWonY Single Call cor duWs up to qX inW,es Cide and double Call cor larger dimensions.

2.T3 6f wR-h Df NRE6 AwwESS 6DDPS

A. hanucaWturers - SubxeW to WomplianWe Cit, reQuirements0 provide produWs by one oc t,e colloCing0or approved eQualY

1. 6uro6yne Mdustries0MW
2. 6uWmate0MW
3. PusI in wompany

B. 6uW-h ounted AWWess 6oorsY: abriWate aWWess panels aWWording to Sh AwNA73k4 (Aw 6uW wonstruWWon Standards - hetal and :leFiblek): igures Q-20k6uW AWWess 6oors and Vanels0k and Q-10kAWWess 6oors - Pound 6uW.k

1. 6oorY

a. 6ouble Call0reWangular.
b. Galvani;ed s,eet metal Cit, insulation cill and t,iWness as indiWated cor duW pressure Wass.
W (ision panel.
d. 4inges and LatW,esYT-by-T-inW butt or piano ,inge and Wam latW,es.
e. :abriWate doors airtig,t and suitable cor duW pressure Wass.

2. :rameYGalvani;ed s,eet steel0Cit, bend-over tabs and coam gasI ets.
3. Number oc4inges and LoWsY

a. AWWess 6oors Less R,an T2 MW,es SQuareYNo ,inges and tCo sas, loWs.
b. AWWess 6oors up to 'TX MW,es/ SQuareYwontinuous and tCo sas, loWs.
W AWWess 6oors up to 2q by qX MW,esYwontinuous and tCo Wompression latW,es Cit, outside and inside ,andles.
d. AWWess 6oors Larger R,an 2q by qX MW,esYwontinuous and tCo Wompression latW,es Cit, outside and inside ,andles.

2.TT 6f wR AwwESS VANEL ASSEh BLMES

A. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0 provide produWts by one oc t, e colloCing0or approved eQualY

1. 6uro6yne Mdustries0MW
2. 6uWmate0MW
3. PusI in wompany

B. Labeled aWWording to f L THQX by an NPRL.

w. Vanel and : rameYh inimum t, iWness 3.3" 2X-inW Warbon steel.

6. : astenersY Stainless steel. Vanel casteners s, all not penetrate duW Call.

E. GasI etYwomply Cit, N: VA Hz) grease-tig, t0, ig, -temperature WeramiWber0rated cor minimum 2333 deg : .

: . h inimum Vressure PatingYT3-inW Cg0positive or negative.

2.T2 : LE[MBLE wDNNEwRDPS

A. h anucaWturers - SubxeW to WomplianWe Cit, reQuirements0 provide produWts by one oc t, e colloCing0or approved eQualY

1. 6uro6yne Mdustries0MW
2. 6uWmate0MW
3. (entcabriWs0MW

B. h aterialsY: lame-retardant or nonWombustible cabriWs.

w. woatings and Ad, esivesYwomply Cit, f L TXT0wlass T.

6. h etal-Edged wonneWorsY: aWtory cabriWated Cit, a cabriWstrip " -15q inW es Cide attaW ed to tCo strips oc2-15q-inW -Cide03.32X-inW -t, iW0galvani; ed s, eet steel or 3.312-inW -t, iW aluminum s, eets. Vrovide metal Wompatible Cit, WonneWted duWs.

E. Mdoor System0: leFible wonneWtor : abriWYGlass cabriWdouble Woated Cit, neoprene.

1. h inimum j eig, tY2z o; .5sO yd..
2. Rensile Strengt, YqX3 lbc5nW in t, e Carp and 1z3 lbc5nW in t, e cilling.
3. ServiWe RemperatureYh inus q3 to plus 233 deg : .

: . Dutdoor System0 : leFible wonneWtor : abriWYGlass cabriWdouble Woated Cit, Ceat, erproo0 synt, etiWrubber resistant to f (rays and o; one.

1. h inimum j eig, tY2q o; .5sO yd..
2. Rensile Strengt, Y" 13 lbc5nW in t, e Carp and qq3 lbc5nW in t, e cilling.
3. ServiWe RemperatureYh inus " 3 to plus 2" 3 deg : .

G. R, rust LimitsY wombination Woil spring and elastomeriW insert Cit, spring and insert in Wompression0 and Cit, a load stop. MWude rod and angle-iron braWets cor attaW ing to can disW arge and duW.

1. : rameYSteel0cabriWated cor WonneWtion to t, readed rods and to alloC cor a maFimum oc13 degrees ocangular rod misalignment Cit, out binding or reduWing isolation eociWenWy.
2. Dutdoor Spring 6iameterYNot less t, an X3 perWent oct, e Wompressed , eig, t oct, e spring at rated load.
3. h inimum Additional RravelY" 3 perWent oct, e reQuired dedeWtion at rated load.
4. Lateral StiocnessYh ore t, an X3 perWent ocrated vertiWal stiocness.
5. Dverload wapaWityY Support 233 perWent oc rated load0 cully Wompressed0 Cit, out decormation or cailure.
6. ElastomeriWElementYh olded0oil-resistant rubber or neoprene.
7. woil SpringY: aWtory set and cield adxustable cor a maFimum ocT5q-inW movement at start and stop.

2.T1 6f wR AwwESSDPU 4AP6j APE

A. Mstrument Rest 4olesYwast iron or Wast aluminum to suit duW material0inWuding sWeC Wap and gasI et. Si; e to alloC insertion ocpitot tube and ot, er testing instruments and oclengt, to suit duW-insulation t, iWness.

B. Ad, esivesY4ig, strengt, 0QuiW setting0neoprene based0Caterprood0and resistant to gasoline and grease.

VAPR 1 - E[EwfRND N

1.T MISRALLARND N

A. Mstall duW aWessories aWording to appliWable details in Sh AwNA7s k4(Aw 6uW wonstruWion Standards - h etal and : leFiblek cor metal duWs and in NAM A A4 TTz0k ibrous Glass 6uW wonstruWion Standards0k cor cibrous-glass duWs.

B. Mstall duW aWessories ocmaterials suited to duW materials) use galvani; ed-steel aWessories in galvani; ed-steel and cibrous-glass duWs0stainless-steel aWessories in stainless-steel duWs0and aluminum aWessories in aluminum duWs.

w. Mstall Wontrol dampers at inlet oceF, aust cans or eF, aust duWs as Wlose as possible to eF, aust can unless ot, erCise indiWated.

6. Mstall volume dampers at points on supply0return0and eF, aust systems C, ere branW, es eFtend crom larger duWs. j , ere dampers are installed in duWs , aving duW liner0install dampers Cit, , at W, annels ocsame dept, as liner0and terminate liner Cit, nosing at , at W, annel.

1. Mstall steel volume dampers in steel duWs.
2. Mstall aluminum volume dampers in aluminum duWs.

E. Set dampers to cully open position becore testing0adxusting0and balanWing.

:. Mstall test , oles at can inlets and outlets and elseC, ere as indiWated.

G. Mstall cire and smol e dampers aWording to f L listing.

4. Mstall duW aWess doors on sides oc duWs to alloC cor inspeWing0adxusting0and maintaining aWessories and eQuipment at t, e colloCing loWationsY

1. Dn bot, sides ocduW Wbils.
2. f pstream crom duW dilters.
3. At outdoor-air intal es and miFed-air plenums.
4. At drain pans and seals.
5. 6 oCnstream crom manual volume dampers0 Wontrol dampers0 baW dract dampers0 and eQuipment.
6. AdxaWent to and WIose enoug, to dire or smol e dampers0 to reset or reinstall cusible linl s. AWWess doors cor aWWess to dire or smol e dampers , aving cusible linl s s, all be pressure reliec aWWess doors and s, all be outCard operation cor aWWess doors installed upstream crom dampers and inCard operation cor aWWess doors installed doCnstream crom dampers.
7. At eaW W, ange in direWtion and at maFimum " 3-coot spaWng.
8. f pstream crom turning vanes.
9. f pstream or doCnstream crom duW silenWers.
10. wontrol deviWes reQuiring inspeWion.
11. ElseC, ere as indiWated.

M Mstall aWWess doors Cit, sCing against duW statiW pressure.

J. AWWess 6 oor Si; esY

1. Dne-4 and or MspeWion AWWessYX by " inW, es.
2. RCo-4 and AWWessYT2 by z inW, es.
3. 4 ead and 4 and AWWessYTX by T3 inW, es.
4. 4 ead and S, oulders AWWessY2T by Tq inW, es.
5. Body AWWessY2" by Tq inW, es.
6. Body plus Ladder AWWessY2" by TQinW, es.

K. Label aWWess doors aWording to SeWion 213" " 1 kMenticWation cor 4 (Aw Viping and EQuipmentk to indiWate t, e purpose ocaWWess door.

L. Mstall deFible WonneWors to WonneW duWs to eQuipment.

h . : or cans developing statiW pressures oc" -inW Cg and more0 Wover deFible WonneWors Cit, loaded vinyl s, eet , eld in plaWe Cit, metal straps.

N. Mstall duW test , oles C, ere reQuired cor testing and balanWng purposes.

D. Mstall t, rust limits at Wenterline oct, rust0 symmetriWal on bot, sides oceQuipment. AttaW t, rust limits at Wenterline oct, rust and adxust to a maFimum ocT5q-inW movement during start and stop occans.

1.2 : MEL6] f ALNRU wDNRPDL

A. Rests and MspeWionsY

1. Dperate dampers to verioy cull range ocmovement.
2. MspeWloWations ocaWWess doors and verioy t, at purpose ocaWWess door Wan be percormed.
3. Dperate dire0 smol e0 and Wombination dire and smol e dampers to verioy cull range oc movement and verioy t, at proper , eat-response deviWe is installed.
4. MspeW turning vanes cor proper and seWre installation.
5. Dperate remote damper operators to verioy cull range ocmovement ocoperator and damper.

EN6 D: SEwRN0N 211133

Section 233416
Centrifugal Hvac Fans

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: For each product.

1. Airfoil centrifugal fans.
2. Plenum fans.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Unusual Service Conditions:

a. Ambient Temperature: 70 deg F.
b. Altitude: 0 feet above sea level.
c. Humidity: 63 deg F.

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

2.2 AIRFOIL CENTRIFUGAL FANS

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

1. Carnes Company
2. Greenheck Fan Corporation
3. Loren Cook Company
4. Penn Barry

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Airfoil Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
5. Discharge Dampers: Assembly with parallel blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
8. Spark-Resistant Construction: AMCA 99.
9. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
10. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.3 PLENUM FANS

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

1. Carnes Company
2. Greenheck Fan Corporation
3. Loren Cook Company
4. Penn Barry

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Airfoil Wheels:

1. Single-width-single-inlet construction with smooth-curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

H. Accessories:

1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
2. Spark-Resistant Construction: AMCA 99.
3. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.5 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction.

F. Unit Support: Install centrifugal fans level on structural curbs. Coordinate wall penetrations and flashing with wall construction.

G. Isolation Curb Support: Install centrifugal fans on isolation curbs and install flexible duct connectors and vibration isolation and seismic-control devices.

1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
2. Comply with requirements in Section 230548.13 "Vibration Controls for HVAC" for vibration isolation devices.

H. Install units with clearances for service and maintenance.

I. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

Section 233713.13
Air Diffusers

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Louver face diffusers.
4. Linear slot diffusers.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.
3. Section 233713.43 "Security Registers and Grilles" for security registers and security grilles.
4. Section 233716 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.

C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.

D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 ROUND CEILING DIFFUSERS

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

1. Kruger
2. Nailor Industries, Inc.
3. Price Industries
4. Titus

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: per Air Device Schedule.

D. Finish: Baked enamel, white.

E. Face Style: per Air Device Schedule.

F. Mounting: Duct connection.

G. Pattern: Fully adjustable.

H. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.2 RECTANGULAR AND SQUARE CEILING DIFFUSERS

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

1. Kruger
2. Nailor Industries, Inc.
3. Price Industries
4. Titus

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: per Air Device Schedule.

D. Finish: Baked enamel, white.

E. Face Size: Air Device Schedule.

F. Face Style: Plaque.

G. Mounting: per Design Documents.

H. Pattern: Adjustable.

I. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.3 LOUVER FACE DIFFUSERS

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

1. Kruger
2. Nailor Industries, Inc.
3. Price Industries
4. Titus

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: per Air Device Schedule.

D. Finish: Baked enamel, white.

E. Mounting: per Design Documents.

F. Pattern: Adjustable core style.

G. Accessories:

1. Square to round neck adaptor.
2. Adjustable pattern vanes.
3. Throw reducing vanes.

4. Equalizing grid.
5. Plaster ring.
6. Safety chain.
7. Wire guard.
8. Sectorizing baffles.
9. Operating rod extension.

2.4 LINEAR BAR DIFFUSERS

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

1. Kruger
2. Nailor Industries, Inc.
3. Price Industries
4. Titus

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: per Air Device Schedule.

D. Finish: Baked enamel, white.

E. Frame: 1 inch (25 mm) wide.

F. Mounting: Concealed bracket.

G. Damper Type: Adjustable opposed-blade assembly.

H. Accessories: Plaster frame, Directional vanes, Alignment pins, Core clips, Blank-off strips.

2.5 LINEAR SLOT DIFFUSERS

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

1. Kruger
2. Nailor Industries, Inc.
3. Price Industries
4. Titus

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material - Shell: per Air Device Schedule.

D. Material - Pattern Controller and Tees: Aluminum.

E. Finish - Face and Shell: Baked enamel, black.

F. Finish - Pattern Controller: Baked enamel, black.

G. Finish - Tees: Baked enamel, white.

H. Accessories: Plaster frame, T-bar slot, Center notch, T-bar on inlet side, T-bar on both sides, T-bar clip on one side, T-bar clips on both sides.

2.6 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

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

END OF SECTION 233713.13

Section 235216
Condensing Boilers

f AVC 5 PEqRqVAL

5T5 VqLACq1 1 - HGNqRCS

AT 1ra. ings and general provisions oD tOe HontraUtM inUuding E eneral and Supplementary Honditions and 1 ivision w5 SpeUIDUation SeUtionsMapply to tOis SeUtionT

5T2 SGNNAVh

AT SeUtion inUudes gasPDredMDrePtubeMDborPmounted Ubndensing boilersMtrimMand aUUessories Dor generating Cot . aterT

5T3 AHCc- R SGBNoCCALS

AT f roduUt 1ataYI or eaUOtype oDproduUtT

5T cnUude UbnstruUtion detailsMmaterial desUriptionsMdimensions oDindividual Ubmponents and proDIesMand DnisOes Dor boilersT
2T cnUude rated UapaUtiesM operating UOaraUteristiUsM and DurnisOed speUialties and aUUessoriesT

BT SOop 1ra. ingsYI or boilersMboiler trimMand aUUessoriesT

5T cnUude plansMelevationsMseUtionsMand attaUOment detailsT
2T cnUude details oDe: uipment assembliesT ndiUate dimensionsM. eigOtsMloadsMre: uired UlearanUesMmetOod oDDeld assemblyMUbmponentsMand loUation and size oDeaUO Deld UbnneUtionT
3T cnUude diagrams Dor po. erMsignalMand Ubntrol . iringT

HT 1elegatedP1 esign SubmittalYI or eaUObboilerT

5T 1esign UalUulations and vibration isolation base detailsMsigned and sealed by a : ualiDed proDessional engineerT

aT 1esign HalUulationsY HalUulate re: uirements Dor seleUting vibration isolators and seismiUrestraints and Dor designing vibration isolation basesT
bT Fibration osolation Base 1etailsY 1etail DabriUationM inUuding anUOorages and attaUOments to struUture and to supported e: uipmentT cnUude ad4ustable motor basesMrailsMand Dames Dor e: uipment mountingT

5T6 dRI - VNACc- RAL SGBNoCCALS

AT Hoordination 1ra. ingsYf lans and seUtionsMdra. n to sUale and Ubordinated . itO eaUO otOerM using input Dom installers oDtOe items involvedT

BT SeismiU " ualiDUation 1ataY HertiDUatesM Dor boilerM aUUessoriesM and UomponentsM Dom manuDaUturerT

5T Basis Dor HertiDUationYondiUate . OetOer . itOstand UertiDUation is based on aUtual test oD assembled Uomponents or on UalUulationT

2T 1imensioned - utline 1ra. ings oDq: uipment GnitYodentiDy Uenter oDgravity and loUate and desUribe mounting and anUOorage provisionsT

3T 1etailed desUription oDe: uipment anUOorage deviUes on . OlUO tOe UertiDUation is based and tOeir installation re: uirementsT

HT SourUe : ualityPUontrol reportsT

1T I ield : ualityPUontrol reportsT

qT Sample x arrantyYI or speUial . arrantyT

IT f roduUt HertiDUatesY

5T ASNq Stamp HertiDUation and VeportY Submit QAMQSMQor Q1f Qstamp UertiDUate oD autOorizationMas re: uired by autOorities Oaving 4urisdiUtionMand doUument OydrostatiU testing oDpiping e, ternal to boilerT

2T HSA B05 pressure vessel Hanadian Vegistration Rumber /HVR7T

5T0 HL- Sq- GC SGBNoCCALS

AT - peration and NaintenanUe 1ataY I or boilers to inUlude in emergenUyMoperationMand maintenanUe manualsT

5T9 x AVVARCh

AT NanuDaUturer;s xarrantyYNanuDaUturer agrees to repair or replaUe UomponentsoDboilers tOat Dail in materials or . orWmansOip . itOn speUDed . arranty periodTx Oere QprorateQis indiUatedMtOe boiler manuDaUturer . ill Uover tOe indiUated perUentage oDUost oDreplaUement partsTx itO QprorateQtypeMUovered Uost deUreases as age oDe: uipment inUreasesT

5T x arranty f eriod Dor I loorPNounted I ireP Cube Hondensing BoilersY

aT 8eat q, UOanger and CanWY1 ree Dom deDeUts in material and . orWmansOipT

bT x arranty HoverageYf rorated hear w to 0 P5ww perUentj hear 9 to k P0w perUentj hear Z to X P3w perUentj hear 5w P5w perUent Dor 0 years Dom date oDSubstantial HompletionT

f AVC 2 Pf V- 1GHCS

2T5 f qVI - VNARHq Vq" GdVqNqRCS

AT qleUtriUal HomponentsMI eviUesMand AUUessoriesYListed and labeled as deDned in RI f A kwMby a : ualiDed testing agenUyMand marWed Dor intended loUation and appliUationT

BT ASNq HomplianUeYI abriUate and label boilers to Ubmply . itOASNq Boiler and f ressure Fessel HodeT

HT AS8 VAq'oqS Xwt5 HomplianUeYBoilers sOall Oave minimum eDDUenUy in aUUordanUe . itOCable 9TZT5P9 and otOer re: uirements in HOT9 oDAS8 VAq'oqS Xwt5T

1T Nounting BaseYI or seUuring boiler to UbnUrete baseT

5T SeismiU I abriUation Ve: uirementsYI abriUate mounting base and attaUOment to boiler pressure vesselMaUUessoriesMand Ubmponents . itO reinDorUement strong enougO to . itOstand seismiU DorUes deDned in SeUtion 23w06Z OFibration and SeismiU HontrolsDor 8FAHQ. Oen mounting base is anUOored to building struUtureT

2T2 I L- - VPN- GROq1M - VHq1P1VAI CM oVqPCGBq H- R1qRSoRE B- dLqVS

AT NanuDaUturers P Sub4eUt to UbmplianUe . itO re: uirementsMprovide produUts by one oDtOe Dollo. ingMor approved e: ualY
5T AerUb
2T Hleaver BrooWs
3T I ulton Boiler x orWs
6T LoUOnvarMLLH
0T x eil NUHlain
9T Feissman Boilers

BT 1esUriptionY I aUtoryPDabriUatedMPassembledMand PestedMDreP ubeMDorUedPdraDMUbndensing boiler . itOOeat e, UOanger sealed pressure tigOtMbuilt on a steel baseMnUuding insulated 4aUWetj DuePgas ventj UbmbustionPair intaWe UbnneUtionsj . ater supplyMreturnMand Ubndensate drain UbnneUtionsj and UbntrolsTGnits are to be Dor . aterPOeating serviUe onlyT

HT f rimary 8eat q, UOangerYHorrosionPesistant Cype 359 stainless steelT

1T SeUbndary 8eat q, UOangerYHorrosionPesistant Cype 359 stainless steelT

qT Hombustion HOamber and I lue f ipesYHorrosionPesistant stainless steel or aluminumT

IT f ressure FesselYHarbon steel . itO. elded Oeads and tube UbnneUtionsT

ET BurnerYRatural gasMDorUed draDT

8T Blo. erYHentriDugal Dan to operate during eaUO burnerPDring se: uenUe and to prepurge and postpurge tOe Ubmbustion UOamberT

5T NotorsYHomply . itORqNA designationMemperature ratingMserviUe DaUtorMand eDDUenUy re: uirements Dor motors speUDed in SeUtion 23w053 OHommon Notor Ve: uirements Dor 8FAHq: uipmentTQ

aT Notor SizesYLarge enougOso driven load . ill not re: uire motor to operate in serviUe DaUtor range above 5TwT

cT Eas CrainYHombination gas valve . itOmanual sOutoDDand pressure regulatorT

JT ognitionY1 ireUPsparWignition or siliUone Uarbide OotPsurDaUe ignition . itO5ww perUent mainPvalve sOutoDDand eleUtroniU Dame supervisionT

KT HasingY

5T JaUWetYSOeet metalM itOsnapPn or interloUWng UosuresT
2T Hontrol Hompartment qnUosuresYRqNA 20wMCype 5AT
3T I inisOYBaWedPenamel or f o. derPUbated proteUtive DnisOT
6T cnsulationY Ninimum 2PnUOPOUWM mineralPDber or polyuretOanePDoam insulation surrounding tOe Oeat e, UOangerT
0T HombustionPAir HonneUtionsYcnlet and vent duUt UbllarsT

2T3 CVdN Pl - V 8 - CPx ACqV B- dLqVS

AT cnUude deviUes sized to Ubmply . itOASNq B35T5T

BT A: uastat HontrollersY- peratingMDring rateMand CigOlimit . itOautomatiUresetT

HT SaDety VelieDFalveYASNq ratedT

1T f ressure and Cemperature EaugeYNinimum 3P5'2PnUOPdiameterMUombination . aterPpressure and Pemperature gaugeTEauges sOall Oave operatingPpressure and Pemperature rangesMso normal operating range is about 0wperUent oDDull rangeT

qT 8igOand lo. gasPpressure s. itUOesT

IT Alarm bell . itOsilenUe s. itUOT

ET Boiler Air FentYAutomatiUT

8T 1rain FalveYNinimum Rf S 3'6 OosePend gate valveT

cT HirUulation fumpY RonoverloadingMinPine pump . itO splitPUapaUtor motor Oaving tOermalP overload proteUtion and lubriUated bearingsj designed to operate at speUDed boiler pressures and temperaturesT

2T6 H- RCV- LS

AT VeDer to SeUtion 23wX23 C1ireUt 1igital Hontrol /1 1H7System Dor 8FAHQand SeUtion 23wXX3T55 QSe: uenUe oD- perations Dor 8FAH 1 1HTQ

BT Boiler operating Ubntrols sOall inUude tOe DollO. ing deviUes and DeaturesY

5T Hontrol transDormerT
2T SetP oint Ad4ustYAll set points sOall be ad4ustableT
3T qleUtriUMaUtoryPabriUated and DaUtoryPnstalled panel to Ubntrol burnerPDring rateMto reset supplyP: ater temperature inversely . itOoutsidePair temperatureT

aT cnUude automatiUMalternatingPDring se: uenUe Dor multiple boilers to ensure ma, imum system eDDUenUy tOrougOout tOe load range and to provide e: ual runtime Dor boilersT

HT Burner - perating HontrolsYCo maintain saDe operating UonditionsMburner saDety Ubntrols limit burner operationT

5T 8igO HutoDDY AutomatiU reset stops burner iDoperating Ubnditions rise above ma, imum boiler design temperatureT

2T Lo. Px ater HutoDDS. itUOYqleUtroniU probe sOall prevent burner operation on lo. . aterT HutoDDs. itUOsOall be automatiUPreset typeT

3T BloUVed cnlet SaDety S. itUOY NanualPreset pressure s. itUO DaUtory mounted on boiler UbmbustionPair inletT

6T Audible AlarmYI aUtory mounted on Ubntrol panel . itOsilenUe s. itUOj sOall sound alarm Dor above UbnditionsT

1T Building Automation System cnterDaUeYI aUtory install Oard. are and soD. are to enable building automation system to monitorMUbntrolMand display boiler status and alarmsT

5T 8ard. ired f ointsY

aT NonitoringY- n'oDDstatusMUbmmon trouble alarm and lo. P. aterPevel alarmT

bT HontrolY- n'oDDoperation and CotP. aterPsupply temperature setPpoint ad4ustmentT

2T A BAHnet UbmmuniUation interDaUe . itO building automation system sOall enable building automation system operator to remotely Ubntrol and monitor tOe boiler Dom an operator . orVstationT All monitoring and Ubntrol DeaturesM. CIUO are available at tOe loUal boiler Ubntrol panelMsOall also be available at tOe remote operator . orVstation tOrougO tOe building automation systemT

2T0 qLqHCVd-HAL f - x qV

AT HontrollersMqleUtriUal 1eviUesMand x iringYqleUtriUal deviUes and UbnneUtions are sOo. n on 1ra. ings and speUDed in eleUtriUal SeUtionsT

BT SinglePoint I ield f o. er HonneUtionYI aUtoryPnstalled and P. ired s. itUOesMmotor UbntrollersM transDormersMand otOer eleUtriUal deviUes neUessary sOall provide a singlePpoint Deld po. er UbnneUtion to boilerT

5T 8ouse in RqNA 20wMCype 5 enUosureT

2T x iring sOall be numbered and Ublor Ubded to matUO. iring diagramT

3T cnstall DaUtory . iring outside oDan enUosure in a metal raUe. ayT

6T I ield po. er interDaUe sOall be to Dused disUbnneUt s. itUOT

0T f rovide branUO po. er UrUuit to eaUO motor and to Ubntrols . itO a disUbnneUt s. itUO or UrUuit breaVerT

9T f rovide eaUO motor . itO overUurrent proteUtionT

2T9 FqRCdRE KdCS

AT KitY Homplete systemMASCN AX0XMCype 2XP6H stainless steel pipeMvent terminalMtOimbleM indoor plateMvent adapterMUbndensate trap and dilution tanVMand sealantT

BT HombustionPAir cntaVeYHomplete systemMstainless steel pipeMvent terminal . itOsUreenMnlet air UbuplingMand sealantT

2Tk H- R1qRSACqPRqGCVALc(ACc- R GRcCS

AT 1esUriptionY I aUtoryPabriUated and Passembled UbndensatePneutralizing Uapsule or tanW assembly oDUbrrosionPesistant plastiU material . itO tOreaded or Danged inlet and outlet pipe UbnneUtionsT1eviUe DunUtions to prevent aUdiU Ubndensate Dom damaging grain systemTct is to be piped to reUeive aUdiU Ubndensate disUOarged Dom Ubndensing boiler and neutralize it by UOemiUal reaUtion . itO replaUeable neutralizing agentTReutralized Ubndensate is tOen piped to suitable drainT

BT Hapsule or CanWeaturesY

5T All UbrrosionPesistant materialT
2T Suitable Dor use on all natural gas and propane boilersT
3T cnUudes initial UOarge oDneutralizing agentT
6T Reutralizing agent to be easily replaUeable . Oen e, OaustedT
0T cnlet and outlet pipe UbnneUtionsT

HT Hapsule HonDguration Y

5T Lo. PproDe design Dor appliUations . Oere boiler Ubndensate drain is Uose to tOe DoorT
2T qasily removed and opened Dor neutralizing agent replaUementT
3T Nultiple units may be used Dor larger UapaUtyT

1T CanWHonDguration Y

5T Gtilized . Oere boiler is elevated or . Oere tanWis installed in a pit . itO tanWtop DusO . itO DoorT
2T Cop easily removed Dor neutralizing agent replaUementT
3T cnternal baDes to UOannel Do. Dor Ubmplete neutralizationT
6T cntegral bypass to prevent Ubndensate baUWo. into applianUeT
0T Nultiple units may be used Dor larger UapaUtyT

2TZ S- GVHq " GALcCh H- RCV- L

AT GL HomplianUeYCest gasPDred boilers Oaving input oDmore tOan 6wwMwww Btu'O Dor UbmplianUe . itO GL kX0TBoilers sOall be listed and labeled by a testing agenUy aUUeptable to autOorities Oaving 4urisdiUtionT

BT GL HomplianUeMEasPiredYCest gasPDred boilers Dor UbmplianUe . itO GL 2k96TBoilers sOall be listed and labeled by a testing agenUy aUUeptable to autOorities Oaving 4urisdiUtionT

HT HSA HomplianUeYCest boilers Dor UbmplianUe . itOARSc(25T53P2w5k'HSA 6TXT

1T f erDormanUe CestingYCest and label boilers Dor eDUenUy to Ubmply . itOA8 Vc50wwT

qT Burner and 8ydrostatiUCestYI aUtory ad4ust burner to eliminate e, Uess o, ygenMUarbon dio, ideM o, ides oDnitrogen emissionsMand Uarbon mono, ide in Due gas and to aUOeve Ubmbustion eDUenUyj perDorm OydrostatiUtestT

I T Cest and inspeUt DaUtoryPassembled boilersMbeDore sCippingMin aUUbrdanUe . itO 2w5k ASNq Boiler and f ressure Fessel HodeTI aUtory test boilers Dor saDety and DunUtionalityj DIl boiler . itO . aterMand Dre tCrougCout Dring rangeMto prove operation oDall saDety UbmponentsT

ET Allo. - . ner aUUess to sourUe : ualityPUbntrol testing oDboilersT RotiDy ArUCteUt 56 days in advanUe oDtestingT

f AVC 3 Pq) qHGCg- R

3T5 q) ANdRACg- R

AT q, amine rougCingPn Dor UbnUrete e: uipment basesManUCorPbolt sizes and loUationsMand piping and eleUtriUal UbnneUtions to veriDy aUtual loUationsMsizesMand otCer Ubnditions aDeUting perDormanUe oDtCe x orWT

5T I inal boiler loUations indiUated on 1 ra. ings are appro, imateT1 etermine e, aUt loUations beDore rougCingPn Dor piping and eleUtriUal UbnneUtionsT

BT q, amine meUCaniUal spaUes Dor suitable Ubnditions . Cere boilers . ill be installedT

HT f roUeed . itO installation only aDer unsatisDaUtory Ubnditions Cave been UbrreUtedT

3T2 B- dLqV dRSCALLACg- R

AT q: uipment NountingY

5T mstall DboorPmounted boilers on UastPnPplaUe UbnUrete e: uipment base/s7T Homply . itO re: uirements Dor e: uipment bases and Doundations speUDed in SeUtion w33www QHastPnP f laUe HonUreteTQ

2T Homply . itO re: uirements Dor vibration isolation and seismiUPrestraint deviUes speUDed in SeUtion 23w06Z QF ibration and SeismiU Hontrols Dor 8 FAHTQ

BT mstall gasPDred boilers aUUbrding to RI f A 06T

HT Assemble and install boiler trimT

1T mstall eleUtriUal deviUes DurnisCed . itO boiler but not speUDed to be DaUtory mountedT

qT mstall Ubntrol . iring to DeldPmounted eleUtriUal deviUesT

3T3 f df dRE H- RRqHCg- RS

AT Homply . itO re: uirements Dor OydroniU piping speUDed in SeUtion 232553 Q8 ydroniU f ipingTQ

BT HonneUt piping to boilersMe, UepU saDety relieDvalve UbnneUtionsM. itO De, ible UbnneUtors oD materials suitable Dor serviUeT I le, ible UbnneUtors and tCeir installation are speUDed in SeUtion 232559 Q8 ydroniU f iping SpeUaltiesTQ

HT 1 ra. ings indiUate general arrangement oDpipingMDttingsMand speUaltiesT

1T x Oen installing piping ad4aUent to boilerMallo. spaUe Dor serviUe and maintenanUe oDUondensing boilersTArrange piping Dor easy removal oDUondensing boilersT

qT cnstall Uondensate drain piping to UondensatePneutralization unit and Dom neutralization unit to nearest Ddor drainTf iping sOall be at least Dull size oDUonneUtionTcnstall piping . itO a minimum oD2 perUent do. n. ard slope in direUtion oDDo. T

IT cnstall Uondensate piping Dom e: uipment drain UonneUtion to nearest Ddor drainTf iping sOall be at least Dull size oDUonneUtionTcnstall piping . itO a minimum oD2 perUent do. n. ard slope in direUtion oDDo. T

ET HonneUt gas piping to boiler gasPtrain inlet . itOunionTf iping sOall be at least Dull size oDgasPtrain UonneUtionTf rovide a reduUer iDre: uiredT

8T HonneUt CotP. ater piping to supplyPand returnPboiler tappings . itO sCutoDDvalveMand union or Dange at eaUO UonneUtionT

cT cnstall piping Dom saDety relieDvalves to nearest Ddor drainT

3T6 1GHC H- RRqHCc- RS

AT Boiler FentingY

5T cnstall DuePenting Wit and UombustionPair intaWeT
2T Homply . itOall boiler manuDaUturer;s installation instruUtionsT
3T I ield Dabriate and install boiler vent and UombustionPair intaWeT
6T Gtilize vent and intaWe duUt materialMsizeMand UnDguration as indiUated in boiler manuDaUturer;s instruUtions and to Ubmply . itOGL 5k3ZT
0T Homply . itOall boiler manuDaUturer;s installation instruUtionsT
9T HonneUt boiler vent Dull size to boiler UonneUtionsT
kT Homply . itOre: uirements in SeUtion 230523 CE as FentsTQ
ZT Homply . itOall boiler manuDaUturer;s installation instruUtionsT

3T0 qLqHCVd-HAL H- RRqHCc- RS

AT HonneUt . iring in aUordanUe . itO SeUtion 29w05X QLo. PFoltage qleUtriUal f o. er HonduUtors and HablesTQ

BT Eround e: uipment aUording to SeUtion 29w029 CE rounding and Bonding Dor qleUtriUal SystemsTQ

HT cnstall eleUtriUal deviUes DurnisOed by manuDaUturerMbut not DaUtory mountedMaUordingto RI f A kwand RqHA 5T

1T cnstall nameplate Dor eaUO eleUtriUal UonneUtionMndiUating eleUtriUal e: uipment designation and UrUuit number Deeding UonneUtionT

5T Rameplate sOall be laminated aUryliU or melamine plastiU signsMas speUDed in SeUtion 29w003 CdentiDUation Dor qleUtriUal SystemsTQ
2T Rameplate sOall be laminated aUryliU or melamine plastiUsigns . itO a blaUWbaUWground and engraved . COte letters at least 5'2 inUOOgOT

3T9 H- RCV- L H- RRqHCc- RS

AT cnstall Ubntrol and eleUtriUal po. er . iring to DeldPmounted Ubntrol deviUesT

BT HonneUt Ubntrol . iring in aUUbrdanUe . itO SeUtion 29w023 QeHontrolPFoltage qleUtriUal f o. er HablesTQ

HT cnstall nameplate Dor eaUO Ubntrol UbnneUtionMndiUating Deld Ubntrol panel designation and c-Ubntrol designation Deeding UbnneUtionT

5T Rameplate sOall be laminated aUryliU or melamine plastiU signsM as speUDed in SeUtion 29w003 QdentiDUation Dor qleUtriUal SystemsTQ
2T Rameplate sOall be laminated aUryliU or melamine plastiU signs . itO a blaUWbaUWground and engraved . Ote letters at least 5'2 inUO OgOT

3Tk I oqL1 " GALcCh H- RCV- L

AT Cesting AgenUyM- . nerY- . ner . ill engage a : ualiDed testing agenUy to perDorm tests and inspeUtionsT

BT Cesting AgenUyMHontraUtorYqngage a : ualiDed testing agenUy to perDorm tests and inspeUtionsT

HT NanuDaUturer;s I ield ServiUeYqngage a DaUtoryPautOorized serviUe representative to test and inspeUt UbmponentsMassembliesMand e: uipment installationsMnUuding UbnneUtionsT

1T f erDorm tests and inspeUtions . itOtOe assistanUe oDa DaUtoryPautOorized serviUe representativeY

qT Cests and cnspeUtionsY

5T f erDorm installation and startup UOeUWs in aUUbrdanUe . itO manuDaUturer;s . ritten instruUtionsT
2T LeaWCestY8 ydrostatiUtestTVepair leaWs and retest until no leaWs e, istT
3T - perational CestYStart units to UbnDrm proper motor rotation and unit operationTAd4ust airPDuel ratio and UbmbustionT
6T Cest and ad4ust Ubntrols and saDetiesTVeplaUe damaged and malDnUtioning Ubntrols and e: uipmentT

aT HOeUWand ad4ust initial operating set points and OgOPand lo. Pimit saDety set points oDDuel supplyM ater levelMand . ater temperatureT
bT Set DeldPad4ustable s. itUOes and UrUuitPbreaWer trip ranges as indiUatedT

I T Boiler . ill be Ubnsidered deDeUtive iDit does not pass tests and inspeUtionsT

ET f repare test and inspeUtion reportsT

8T - UUupanUy Ad4ustmentsYx Oen re: uested . itOin 52 montOs oDdate oDSubstantial HompletionM provide onPsite assistanUe in ad4usting system to suit aUtual oUUupied UbnditionsTf rovide up to t. o visits to f ro4eUt during otOerPOanPnormal oUUupanUy Oours Dor tOis purposeT

3TZ 1qN- RSCVACG- R

AT qngage a DaUtoryPautOorized serviUe representative to train - . ner;s maintenanUe personnel to ad4ustMoperateMand maintain boilersTVeDer to SeUtion w5kXwwCl emonstration and CrainingTQ.

5T onstruUtor sOall be DaUtory trained and UertiDedT
2T f rovide not less tOan t. o Oours oDtrainingT
3T Crain personnel in operation and maintenanUe and to obtain ma, imum eDDUenUy in plant operationT
6T f rovide instruUtional videos sOo. ing general operation and maintenanUe tOat are Uordinated . itO operation and maintenanUe manualsT
0T - btain - . ner signPoDDtOat training is UompleteT
9T - . ner training sOall be Oeld at f ro4eUt siteT

qR1 - I SqHCG- R 230259

Section 236200
Packaged Compressor And Condenser Units

WA- GEN. DwD- AL

EfE - DLAGDh hCRTc DwGS

Af hra, ings and general provisions o0 tUe RontraVtMinVluding . eneral and Supplementary Ronditions and hivision 6E SpeVi0Vation SeVtionsMapply to tUis SeVtionf

Ef2 STc c A- Y

Af SeVtion inVludes paVPagedMre0rigerant Vompressor and Vondenser unitsf

Ef1 WD- I C- c AwRD - D: TF= Dc DwGS

Af SeismiV WerformanVeO Rompressor and Vondenser units sUall , itUstand tUe e0eVts o0 eartUQuaPe motions determined aVVording to ASRDkSDF4f

Ef GUe term (, itUstand(means (tUe unit , ill remain in plaVe , itUout separation o0 any parts 0rom tUe deviVe , Uen sub)eVted to tUe seismiV 0orVes speVi0ed and tUe unit , ill be 0ully operational a0er tUe seismiV eventf(

Efj ARGFCw STBc FGGALS

Af WroduVt hataOI or eaVU Vompressor and Vondenser unitf FnVlude rated VapaVitiesMoperating VUaraVteristiVsMand 0urnisUed speVialties and aVVessoriesf FnVlude eQuipment dimensionsM, eigUts and struVtural loadsMreQuired VlearanVesMmetUod o00eld assemblyMVomponentsMand loVation and siqe o0eaVU 0eld VonneVtionf

Bf LDDh SubmittalsO

Ef WroduVt hata 0or WereQuisite DA 2O hoVumentation indiVating tUat units Vomply , itU appliVable reQuirements in AS" - ADkFDSwA z6fEf

2f WroduVt hata 0or Rredit DA j O hoVumentation indiVating tUat Vompressor and Vondenser units and re0rigerants Vomplyf

Rf SUop hra, ingsOI or Vompressor and Vondenser unitsf FnVlude plansM elevationsM seVtionsM detailsM and attaVUments to otUer , orPf

Ef H iring hiagramsOI or po, erMsignalMand VontroI , iringf

hf helegatedNhesign SubmittalOI or Vompressor and Vondenser units indiVated to Vomply , itU per0ormanVe reQuirements and design VriteriaMnVluding analysis data signed and sealed by tUe Quali0ed pro0essional engineer responsible 0or tUeir preparationf

Ef 7ibration Fsolation Base hetailsOhetail 0abriVation inVluding anVUbrages and attaVUments to struVture and to supported eQuipmentf FnVlude ad)ustable motor basesMrailsMand 0rames 0or eQuipment mountingf

2f hesign RalVulationsORalVulate reQuirements 0or seleVting vibration isolators and seismiV restraints and 0or designing vibration isolation basesf

Ef; FwI C- c AGFCwAL STBc FGGALS

Af Roordination hra, ingsOWansMdra, n to sValeMon , UiVU tUe 0oIlo, ing items are sUo, n and Voordinated , itU eaVU otUerMbased on input 0rom installers o0tUe items involvedO

Ef StruVtural members to , UiVU Vompressor and Vondenser units , ill be attaVUedf

2f LiQuid and vapor pipe siqesf

1f - e0igerant speVialtiesf

j f WIping inVluding VonneVtionsMoil trapsMand double risersf

; f Rompressorsf

3f Dvaporatorsf

Bf SeismiV : uali0Vation Rerti0VationOI or Vompressor and Vondenser unitsMaWessoriesMand VomponentsM0rom manu0aVturerf

Ef Basis 0or Rerti0VationOFndiVate , UetUer , itUstand Verti0Vation is based on aVtual test o0 assembled Vomponents or on ValVulationf

2f himensioned Cutline hra, ings o0 DQuipment TnitOFdenti0y Venter o0 gravity and loVate and desVribe mounting and anVUbrage provisionsf

1f hetailed desVription o0 eQuipment anVUbrage deviVes on , UiVU tUe Verti0Vation is based and tUeir installation reQuirementsf

Rf I ield QualityNVontrol reportsf

hf HarrantyOSample o0speVial , arrantyf

Ef3 RLCSDCTGSTBc FGGALS

Af Cperation and c aintenanVe hataOI or Vompressor and Vondenser units to inVlude in emergenVyMoperationMand maintenanVe manualsf

Ef4 : TALFGY ASST- AwRD

Af DleVtriVal RomponentsMheviVesMand AWessoriesOListed and labeled as de0ned in wI WA 46Mby a Quali0ed testing agenVyMand marPed 0or intended loVation and appliVationf

Bf I abriVate and label re0rigeration system aWording to AS" - AD E; M(Sa0ety Standard 0or - e0rigeration Systemsf(

Rf AS" - ADkFDSwA z6fE RomplianVeO AppliVable reQuirements in AS" - ADkFDSwA z6fEM SeVtion 3M (" eatingM 7entilatingMand AirNRonditioningf(

Ef5 RCC- h FwAGFCw

Af Roordinate siqes and loVations o0 VonVrete basesf Rast anVUornNbolt inserts into basesf RonVreteMreinQrVementM and Qorm, orP reQuirements are speVi0ed in SeVtion 611666 (RastNFnNWaVe RonVrete(and SeVtion 6116; 1 (c isVellaneous RastNFnNWaVe RonVretef(

Bf Roordinate installation o0 roo0 VurbsMeQuipment supportsMand roo0 penetrationsf GUese items are speVi0ed in SeVtion 644266 (- oo0AVVessoriesf(

Rf Roordinate loVation o0piping and eleVtriVal rougUnhsf

Efz H A- - AwGY

Af SpeVial H arrantyOc anuQaVturerXs standard Qorm in , UiVU manuQaVturer agrees to repair or replaVe Vomponents o0 Vompressor and Vondenser units tUat Qail in materials or , orPmansUip , itUin speVi0ed , arranty periodf

Ef I ailures inVludeMbut are not limited toMtUe Qollo, ingO

af Rompressor Qailuref
bf Rondenser Voil leaPf

2f H arranty WeriodOI ive years Qrom date o0Substantial Rompletionf
1f H arranty Weriod xRompressor CnlyJOG, o years Qrom date o0Substantial Rompletionf
j f H arranty Weriod xRomponents CtUer GUan RompressorJOI ive years Qrom date o0Substantial Rompletionf
; f H arranty Weriod xRondenser Roil CnlyJOI ive years Qrom date o0Substantial Rompletionf

WA- G2 NW- Ch TRGS

2fE RCc W- DSSC- Awh RCwh DwSD- TwFGSMAF- RCCLDh ME GC ; GCwS

Af c anuQaVturersOSub)eVt to VomplianVe , itU reQuirementsMprovide produVts by one o0 tUe Qollo, ing or approved eQualO

Ef Rarrier Rorporation/ a unit o0Tnited GeVUnologies Rorpf

2f h aiPin
1f Lenno8 FndustriesMFnVf/ Lenno8 Fnternationalf
j f - Ueem c anuQaVturing Rompany/ " eating and Rooling WroduVtsf
; f - uud Air Ronditioning h ivisionf
3f Granef
4f YC- K/ a 9oUnson Rontrols Vompanyf

Bf h esVriptionOI aVtory assembled and tested/ Vonsisting o0 VompressorMVondenser VoilMQanMmotorsMreQrigerant reservoirMand operating VontrolsfI or use in 7- I systemsf

Rf RompressorOFnvertor SVrollMUermetiVally sealedM itU rubber vibration isolatorsf

Ef c otorODRc 7I h and inVludes tUermalNand VurrentNsensitive overload deviVesMstart VapaVitorMrelayMand VontaVtorf

2f RompressorOFnVlude manualNtesetMUigUNpressure s, itVU and automatiVNtesetMo, Npressure s, itVUf
1f AVVumulatorOSuVtion tubef

hf - e0rigerantO- NjE6Af

Df Rondenser RoilOSeamless VopperNtubeMaluminumM0n Voil/ VirVuited 0or integral liQuid subVoolerM, itU removable drain pan and brass serviVe valves , itU serviVe portsf

I f Rondenser I anOh ireVtNdriveMaluminum propeller 0an/ , itU permanently lubriVatedMDRc 0an motor , itU tUermalN overload proteVtion' and ball bearings[f

. f AVVessoriesO
Ef RranPVase Ueaterf
2f RyVle WroteVtorOAutomatiVNteset timer to prevent rapid Vompressor VyVlingf
1f DleVtroniV programmable tUermostat Lo, Nvoltage tUermostat and subbase to Vontrol Vompressor and Vondenser unit and evaporator 0an 0or 7- I systemf
j f Dvaporator I reeqe GUermostatOGemperatureNaVtuated s, itVU tUat stops unit , Uen evaporator reaVUes 0reeqing temperaturef
; f I ilterNdryerf
3f " igUNWessure S, itVUOAutomatiVNteset s, itVU VyVles Vompressor o0Don UigU re0rigerant pressuref
4f LiQuidNline solenoidf
5f Lo, NAmbient RontrollerORontrols Vondenser 0an speed to permit operation do, n to minus 2; deg I , itU timeNdelay relay to bypass lo, Npressure s, itVUf
zf Lo, NWessure S, itVUOAutomatiVNteset s, itVU VyVles Vompressor o0Don lo, re0rigerant pressuref
E6f WD mounting basef
EEf WreVUarged and insulated suVtion and liQuid tubingf
E2f Sound " oodOH raps around sound attenuation Vover 0or Vompressorf
E1f GUermostatiV e8pansion valvef
Ej f GimeNh elay - elayORontinues operation o0evaporator 0an a0er Vompressor sUuts o0Of
E; f - eversing valvef

" f Tnit RasingO. alvaniqed steelM0nisUed , itU baPed enamel/ , itU removable panels 0or aVVess to VontrolsM, eep Uoles 0or , ater drainageMand mounting Uoles in basef c ount serviVe valvesM0ttingsMand gage ports on e8terior o0 Vasingf

Ff RapaVities and RUaraVteristiVsOSee RontraVt h ra, ingsf

2f2 RCc W- DSSC- Awh RCwh DwSD- TwFGSMAF- RCCLDh M8 GC E26 GCwS

Af c anu0aVturersOSub)eVt to VomplianVe , itU reQuirementsMprovide produVts by one o0tUe 0ollo, ingO

Ef Rarrier Rorporation/ a unit o0Tnited GeVUnologies Rorpf
2f Rontinental WroduVtsf
1f h aiPin
j f h unUamNBusUMFnVf
; f Dngineered Airf
3f Lenno8 FndustriesMFnVf/ Lenno8 Fnternationalf
4f - Ueem c anu0aVturing Rompany/ " eating and Rooling WroduVtsf

5f - uud Air Ronditioning h ivisionf
zf Granef
E6f YC- K/ a 9oUnson Rontrols Vompanyf

Bf hesVriptionOI aVtory assembled and testedMair Vooled/ Vonsisting o0 VasingMVompressorsMVondenser VoilsM Vondenser 0ans and motorsMand unit Vontrols 0or use in 7- I systemsf

Rf RompressorOFnvertor " ermetiV sVroll Vompressor designed 0or serviVe , itU VranPVase sigUt glassMVranPVase UeaterMand baVPseating serviVe aVVess valves on suVtion and disVUarge portsf

Ef RapaVity RontrolO7 ariableNreQuenVy Vontroller " otNgas bypassf

hf - e0rigerantO- NjE6Af

Df Rondenser RoilOSeamless VopperNtubeMaluminumN0n VoilMnVluding subVooling VirVuit and baVPseating liQuidNline serviVe aVVess valvef I aVtory pressure test VoilsMtUen deUydrate by dra, ing a vaVuum and 0ll , itU a Uolding VUarge o0nitrogen or re0rigerantf

I f Rondenser I ansOVropellerNtype vertiVal disVUarge/ direVtly drivenf FnVlude tUe 0ollo, ingO

Ef Wermanently lubriVatedMballNbearing DRc or 7I h motorsf
2f Separate motor 0or eaVU 0anf
1f h ynamiVally and statiVally balanVed 0an assembliesf

. f Cperating and sa0ety Vontrols inVlude tUe 0ollo, ingO

Ef c anualNresetMUigUNpressure Vutout s, itVUesf
2f AutomatiVNresetMo, Npressure Vutout s, itVUesf
1f Lo, NoilNpressure Vutout s, itVUf
j f RompressorN, inding tUermostat Vutout s, itVUf
; f GUreeNlegMVompressorNoverload proteVtionf
3f Rontrol trans0ormerf
4f c agnetiV VontaVtors 0or Vompressor and Vondenser 0an motorsf
5f Gimer to prevent e8Vessive Vompressor VyVlingf

" f AVVessoriesO

Ef DleVtroniV programmable tUermostat Lo, Nvoltage tUermostat and subbase to Vontrol Vompressor and Vondenser unit and evaporator 0an 0or 7- I systemf
2f Lo, NAmbient RontrollerORontrols Vondenser 0an speed to permit operation do, n to minus 2; deg I , itU timeNdelay relay to bypass lo, Npressure s, itVUf
1f . age WanelOWaVPage , itU re0rigerant VirVuit suVtion and disVUarge gagesf
j f " otNgas bypass PItf
; f WartN, indingNstart timing relayMVirVuit breaPersMand VontaVtorsf
3f - eversing valvef

Ff Tnit RasingsOh esigned 0or outdoor installation , itU , eatUer proteVtion 0or Vomponents and Vontrols and , itU removable panels 0or reQuired aVVess to VompressorsMVontrolsMVondenser 0ansMmotorsMand drivesf Additional 0eatures inVlude tUe 0ollo, ingO

Ef SteelMgalvaniqed or qinV VoatedM0or e8posed Vasing sur0aVes/ treated and 0nisUed , itU manu0aVturerXs standard paint Voatingf
2f Werimeter base rail , itU 0orPli0t slots and li0ting Uoles to 0aVilitate riggingf

1f . asPeted Vontrol panel doorf
j f won0used disVonneVt s, itVUMaVtory mounted and , iredM0or single e8ternal eleVtriVal po, er VonneVtionf
; f Rondenser Voil Uail guard grillef

9f RapaVities and RUaraVteristiVsOSee RontraVt h ra, ingsf

2f1 c CGC- S

Af Romply , itUwDc A designationMtemperature ratingMserviVe 0aVtorMenVlosure typeMand e0MenVy reQuirements 0or motors speVi0ed in SeVtion 216; E1 (Rommon c otor - eQuirements 0or " 7AR DQuipmentf(

Ef c otor SiqesOc inimum siqe as indiVatedf F0not indiVatedMarge enougUso driven load , ill not reQuire motor to operate in serviVe 0aVtor range above Ef6f

2fj SCT- RD : TALFGY RCwG- CL

Af 7eri0Vation o0We0ormanVeO- ate Vompressor and Vondenser units aVWording to A- F263kEE6 A- F163kEE6f

Bf Dnergy D0MenVyODQual to or greater tUan presVribed by AS" - ADkFDSwA z6fEM(Dnergy D0MVent h esign o0we, Buildings e8Vept Lo, N ise - esidential BuildingsM(SeVtion 3M(" eatingM7entilatingMand AirNRonditioningf(

Rf Gest and inspeVt sUell and tube Vondensers aVWording to ASc D Boiler and Wressure 7essel RodeOSeVtion 7FFFM h ivision Ef

h f Gesting - eQuirementsOl aVtory test soundNpo, erNevel ratings aVWording to A- F246 A- F146f

WA- G1 ND] DRTGFCw

1fE D] Ac FwAGFCw

Af D8amine substratesMareasMand VonditionsM, itUFnstaller presentM0or VomplianVe , itU reQuirements 0or installation toleranVes and otUer Vonditions a0eVting per0ormanVe o0Vompressor and Vondenser unitsf

Bf D8amine rougUingNh 0or re0rigerant piping systems to veri0y aVtual loVations o0 piping VonneVtions be0ore eQuipment installationf

Rf D8amine , allsM0oorsMand roo0s 0or suitable Vonditions , Uere Vompressor and Vondenser units , ill be installedf

h f WroVeed , itU installation only a0er unsatis0aVtory Vonditions Uave been VorreVtedf

1f2 FwSGALLAGFCw

Af Fnstall units level and plumbM0rmly anVUored in loVations indiVatedf

Bf Fnstall roo0Nmounting units on eQuipment supports speVi0ed in SeVtion 644266 (- oo0AVVessoriesf(

Rf DQuipment c ountingO

Ef Fnstall Vompressor and Vondenser units on VastNihNplaVe VonVrete eQuipment basesf Romply , itU reQuirements 0or eQuipment bases and 0oundationsf

2f Romply , itU reQuirements 0or vibration isolation and seismiV Vontrol deviVes speVi0ed in SeVtion 216; j 5 (7ibration and SeismiV Rontrols 0or " 7ARf(

1f Romply , itU reQuirements 0or vibration isolation deviVes speVi0ed in SeVtion 216; j 5fE1 (7ibration Rontrols 0or " 7ARf(

hf c aintain manu0aVturerXs reVommended VlearanVes 0or serviVe and maintenanVef

Df Loose RomponentsOFnstall eleVtriVal VomponentsMdeviVesMand aVVessories tUat are not 0aVtory mountedf

1f1 RCwwDRGFCwS

Af Romply , itU reQuirements 0or piping in otUer SeVtion 212EE1 (" ydroniV Wiping(and SeVtion 212EE3 " ydroniV Wiping SpeVialtiesf(h ra, ings indiVate general arrangement o0pipingM0ttingsMand speVialtiesf

Bf H Uere installing piping ad)aVent to eQuipmentMallo, spaVe 0or serviVe and maintenanVe o0eQuipmentf

Rf RonneVt preVUarged re0rigerant tubing to unitXs QuiVPNVonneVt 0ttingsf Fnstall tubing so it does not inter0ere , itU aVVess to unitf Fnstall 0urnisUed aVVessoriesf

hf RonneVt re0rigerant piping to airNVooled Vompressor and Vondenser units/ maintain reQuired aVVess to unitf Fnstall 0urnisUed 0eldNmounted aVVessoriesf - e0rigerant piping and speVialties are speVi0ed in SeVtion 212166 (- e0rigerant Wipingf(

1fj I FDLh : TALFGY RCwG- CL

Af Wer0orm tests and inspeVtionsf

Ef c anu0aVturerXs I ield ServiVeODngage a 0aVtoryNautUoriqed serviVe representative to inspeVtMtestMand ad)ust VomponentsMassembliesMand eQuipment installationsMinVluding VonneVtionsMand to assist in testingf

Bf Gests and FnspeVtionsO

Ef Wer0orm eaVU visual and meVUaniVal inspeVtion and eleVtriVal testf Rerti0y VomplianVe , itU test parametersf

2f LeaP GestOA0er installationMVUarge system , itU re0rigerant and oil and test 0or leaPsf - epair leaPsMreplaVe lost re0rigerant and oilMand retest until no leaPs e8istf

1f Cperational GestOA0er eleVtriVal VirVuitry Uas been energiqedMstart units to Von0rm proper motor operation and unit operationMproduVt VapabilityMand VomplianVe , itU reQuirementsf

jf Gest and ad)ust Vontrols and sa0etiesf - eplaVe damaged and mal0unVtioning Vontrols and eQuipmentf

; f 7eri0y proper air0lo, over Voilsf

Rf 7eri0y tUat vibration isolation and 0le8ible VonneVtions properly dampen vibration transmission to struVturef

hf Rompressor and Vondenser units , ill be Vonsidered de0eVtive i0tUey do not pass tests and inspeVtionsf

Df Wrepare test and inspeVtion reportsf

1f; SGA- GTWSD- 7FRD

Af Dngage a 0aVtoryNautUoriqed serviVe representative to per0orm startup serviVef

Ef Romplete installation and startup VUeVPs aVVording to manu0aVturerXs , ritten instruVtions and per0orm tUe 0ollo, ingO

af FnspeVt 0or pUysiVal damage to unit Vasingf
bf 7eri0y tUat aVVess doors move 0reely and are , eatUertigUtf
Vf Rlean units and inspeVt 0or VonstruVtion debrisf
df 7eri0y tUat all bolts and sVre, s are tigUtf
ef Ad)ust vibration isolation and 0le8ible VonneVtionsf
0f 7eri0y tUat Vontrols are VonneVted and operationalf

Bf LubriVate bearings on 0an motorsf

Rf 7eri0y tUat 0an , Ueel is rotating in tUe VorreVt direVtion and is not vibrating or bindingf

hf Ad)ust 0an belts to proper alignment and tensionf

Df Start unit aVVording to manu0aVturerXs , ritten instruVtions and Vomplete manu0aVturerXs startup VUeVPistf

l f c easure and reVord air0lo, and air temperature rise over Voilsf

. f 7eri0y proper operation o0Vondenser VapaVity Vontrol deviVef

" f 7eri0y tUat vibration isolation and 0le8ible VonneVtions properly dampen vibration transmission to struVturef

Ff A0ter startup and per0ormanVe testMubriVate bearingsf

1f3 hDc CwSG- AGFCw

Af Dngage a 0aVtoryNautUoriqed serviVe representative to train C, nerXs maintenanVe personnel to ad)ustMoperateM and maintain Vompressor and Vondenser unitsf

Dwh CI SDRGFCw 213266

Section 237416.11
Packaged, Small-Capacity, Rooftop Air-Conditioning Units

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:

1. Casings.
2. Fans, drives, and motors.
3. Rotary heat exchangers.
4. Coils.
5. Refrigerant circuit components.
6. Air filtration.
7. Gas furnaces.
8. Dampers.
9. Electrical power connections.
10. Controls.
11. Roof curbs.
12. Accessories.

1.3 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.4 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.

d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include gas furnaces with performance characteristics.
9. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, small-capacity, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and [mounting] [attachment] details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Wind-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control reports.

F. System startup reports.

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) of filters for each unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each belt-driven fan.
4. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE 15 Compliance: For refrigeration system safety.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

1. Design RTU supports to comply with wind and seismic performance requirements.

H. Wind-Restraint Performance:
1. Refer to structural contract documents.

I. Seismic Performance: RTUs, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.0.
3. Refer to structural contract documents.

2.2 MANUFACTURERS

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

B. Carrier

C. Daiken

D. Trane

E. York/JCI

2.3 UNIT CASINGS

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

B. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
2. Inside Casing Wall: G90-coated galvanized steel, 0.034 inch thick.
3. Floor Plate: G90 galvanized steel, treadplate, minimum 18 gauge thick.
4. Casing Insulation:

a. Materials: Injected polyurethane foam insulation.
b. Casing Panel R-Value: Minimum R13.
c. Insulation Thickness: 2 inches.
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg.
2. For Unit Sections Downstream and Including Fans

E. Panels and Doors:

1. Panels:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

2. Access Doors:

a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Locations and Applications:

a. Fan Section: Doors.
b. Access Section: Doors.
c. Coil Section: Inspection and access panels.
d. Damper Section: Inspection and access panels.
e. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

F. Condensate Drain Pans:

1. Location: Each type of cooling coil.
2. Construction:

a. Single-wall, galvanized-steel sheet.

3. Drain Connection:

a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
b. Minimum Connection Size: 1 1/4.

4. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.

    a. Turned, ground, and polished hot-rolled steel with keyway.

2. Shaft Bearings:

    a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.

3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

    a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
6. Shaft Lubrication Lines: Extended to a location outside the casing.
7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Drives, Direct: Factory-mounted, direct drive.

D. Drives, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.

3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

E. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.

F. Relief-Air Fan: Propeller, shaft mounted on permanently lubricated motor.

G. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure Type: Open, dripproof or Totally enclosed, fan cooled.
4. Enclosure Materials: Cast iron.

5. Efficiency: Premium efficient as defined in NEMA MG 1.
6. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
7. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.5 COILS

A. General Requirements for Coils:

1. Comply with AHRI 410.
2. Fabricate coils section to allow for removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Supply-Air Refrigerant Coil:

1. Tubes: Copper.
2. Fins:

   a. Material: Aluminum.
   b. Fin Spacing: Maximum 12 fins per inch.

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Stainless steel.
6. Coatings: Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

   a. Working Pressure: Minimum 300 psig.

C. Outdoor-Air Refrigerant Coil:

1. Tubes: Copper.

2. Fins:

    a. Material: Aluminum.
    b. Fin Spacing: Maximum 12 fins per inch.

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Stainless steel.
6. Coatings: Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

    a. Working Pressure: Minimum 300 psig.

D. Hot-Gas Reheat Refrigerant Coil:

1. Tubes: Copper.
2. Fins:

    a. Material: Aluminum.
    b. Fin Spacing: Maximum 12 fins per inch.

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Stainless steel.
6. Coatings: Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

    a. Working Pressure: Minimum 300 psig.

8. Suction-discharge bypass valve.

E. Electric-Resistance Heating Coils: Comply with UL 1995.

1. Casing Assembly: Slip-in or Flanged type with galvanized-steel frame.
2. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
3. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
4. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
5. Control Panel: Unit mounted with disconnecting means and overcurrent protection.

    a. Magnetic contactor.
    b. Solid-state, stepless pulse controller.
    c. Toggle switches, one per step.
    d. Step controller.
    e. Time-delay relay.
    f. Pilot lights, one per step.
    g. Airflow proving switch.

2.6 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, variable-speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.
11. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
12. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.7 AIR FILTRATION

A. Panel Filters:

1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

2.8 GAS FURNACES

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated Minimum Turndown Ratio: 30 to 1.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

D. Heat-Exchanger and Drain Pan: Stainless steel.

E. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

F. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.

2.9 DAMPERS

A. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in parallel-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

B. Barometric relief dampers.

C. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
    e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): 24 V dc.
11. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

12. Temperature Rating: Minus 22 to plus 122 deg F.
13. Run Time: 12 seconds open, 5 seconds closed.

2.10 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.11 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

B. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. Automatic changeover.
    e. Adjustable deadband.
    f. Concealed set point.
    g. Exposed indication.
    h. Degree F indication.
    i. Unoccupied-period-override push button.
    j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.

C. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

    a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
    b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
    c. Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 284621.11 "Addressable Fire-Alarm Systems."
    d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than 40 deg F.
    e. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

3. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
4. Unoccupied Period:

a. Heating Setback: 10 def F.
b. Cooling Setback: System off.
c. Override Operation: two hours.

5. Supply Fan Operation:

a. Occupied Periods: Run fan continuously.
b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

a. Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass to match compressor output to cooling load to maintain room or discharge temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.

7. Hot-Gas Reheat-Coil Operation:

a. Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles the compressor.
b. Unoccupied Periods: Reheat not required.

8. Gas Furnace Operation:

a. Occupied Periods: Modulate burner to maintain room or discharge temperature.
b. Unoccupied Periods: Cycle burner to maintain setback temperature.

9. Electric-Heating-Coil Operation:

a. Occupied Periods: Modulate coil to maintain room or discharge temperature.
b. Unoccupied Periods: Energize coil to maintain setback temperature.
c. Operate supplemental electric heating coil with compressor for heating with outdoor temperature below 25 deg F.

10. Carbon Dioxide Sensor Operation:

a. Occupied Periods: Reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 800 ppm concentration.
b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

11. Terminal-Unit Relays:

a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.

3. Provide BACnet compatible interface for central HVAC control workstation for the following:

    a. Adjusting set points.
    b. Monitoring supply fan start, stop, and operation.
    c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
    d. Monitoring occupied and unoccupied operations.
    e. Monitoring constant and variable motor loads.
    f. Monitoring variable-frequency drive operation.
    g. Monitoring cooling load.
    h. Monitoring economizer cycles.
    i. Monitoring air-distribution static pressure and ventilation air volume.

2.12 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C1071, Type I or II.
    b. Thickness: 2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    d. Liner Adhesive: Comply with ASTM C916, Type I.

C. Curb Dimensions: Height of 24 inches. Adaptable horizontal dimensions as required for existing roof openings.

2.13 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Low-ambient kit using variable-speed condenser fans for operation down to 35 deg F.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Remote potentiometer to adjust minimum economizer damper position.

E. Return-air bypass damper.

F. Factory- or field-installed, demand-controlled ventilation.

G. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.
5. Gas furnace or Electric coil airflow-proving switch.

H. Coil guards of painted, galvanized-steel wire.

I. Hail guards of galvanized steel, painted to match casing.

J. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

K. Door switches to disable heating or reset set point when open.

L. Outdoor-air intake weather hood.

M. Oil separator.

N. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

2.14 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

2.15 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

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

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

B. Unit Support: Install unit level on structural curbs or steel supports. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Equipment Mounting:

1. Install RTUs on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 PIPING CONNECTIONS

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

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

F. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
3. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. RTU will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect for visible damage to unit casing.
3. Inspect for visible damage to furnace combustion chamber.
4. Inspect for visible damage to compressor, coils, and fans.
5. Inspect internal insulation.
6. Verify that labels are clearly visible.
7. Verify that clearances have been provided for servicing.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Clean condenser coil and inspect for construction debris.
11. Clean furnace flue and inspect for construction debris.
12. Connect and purge gas line.
13. Remove packing from vibration isolators.
14. Inspect operation of barometric relief dampers.
15. Verify lubrication on fan and motor bearings.
16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
17. Adjust fan belts to proper alignment and tension.
18. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

19. Inspect and record performance of interlocks and protective devices; verify sequences.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency:

    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

28. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.

30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 CLEANING

A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. RTU will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.12 DEMONSTRATION

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

END OF SECTION 237416.11

Section 238126
Split-System Air-Conditioners

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each air-handling unit fan.

1.7 QUALITY ASSURANCE

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

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts: Five year(s) from date of Substantial Completion.
c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Carrier Corporation; a unit of United Technologies Corp.
2. Daikin
3. Lennox Industries, Inc.; Lennox International.
4. Mitsubishi Electric & Electronics USA, Inc.
5. SANYO North America Corporation.
6. Trane.
7. YORK; a Johnson Controls company.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch; leak tested to 300 psig underwater; with a two-position control valve.
5. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
7. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Wiring Terminations: Connect motor to chassis wiring with plug connection.

8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Filters: Permanent, cleanable.
10. Condensate Drain Pans:

    a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.

2) Depth: A minimum of 2 inches deep.

b. Single-wall, stainless-steel sheet.
c. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

1) Minimum Connection Size: NPS 1.

e. Pan-Top Surface Coating: Asphaltic waterproofing compound.
f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
f. Mount unit-mounted disconnect switches on exterior of unit.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:

a. Fabricated with [one] [two] percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 1 inch deep.

b. Single-wall, stainless-steel sheet.
c. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.

1) Minimum Connection Size: NPS 1.

e. Pan-Top Surface Coating: Asphaltic waterproofing compound.

8. Air Filtration Section:

a. General Requirements for Air Filtration Section:

1) Comply with NFPA 90A.
2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Disposable Panel Filters:

1) Factory-fabricated, viscous-coated, flat-panel type.
2) Thickness: 1 inch.
3) Dust-Holding Capacity.
4) Initial Resistance: 0.10 inches wg.
5) Recommended Final Resistance: 0.20 inches wg.
6) Arrestance according to ASHRAE 52.1: 80.
7) Merv according to ASHRAE 52.2: 8.
8) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
9) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

c. Extended-Surface, Disposable Panel Filters:

1) Factory-fabricated, dry, extended-surface type.
2) Thickness: 1 inch 2 inches.
3) Dust-Holding Capacity.
4) Initial Resistance: 0.10 inches wg.
5) Recommended Final Resistance: 0.20 inches wg.
6) Arrestance according to ASHRAE 52.1: 90.
7) Merv according to ASHRAE 52.2: 8.
8) Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.
9) Media-Grid Frame: Nonflammable cardboard Galvanized steel Fire-retardant, 3/4-inch particleboard with gaskets.

2.3 INDOOR UNITS (6 TONS OR MORE)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch; leak tested to 300 psig underwater; with a two-position control valve.
5. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
7. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection.
    d. Wiring Terminations: Connect motor to chassis wiring with plug connection.

8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Filters: 1 inch thick, in fiberboard frames Permanent, cleanable.
10. Condensate Drain Pans:

    a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
        2) Depth: A minimum of 2 inches deep.

    b. Single-wall, stainless-steel sheet.
    c. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
    d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.

        1) Minimum Connection Size: NPS 1.

    e. Pan-Top Surface Coating: Asphaltic waterproofing compound.
    f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Variable-Frequency Controllers:

1. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, three-phase induction motor by adjusting output voltage and frequency.
2. Output Rating: Three-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

3. Unit Operating Requirements:

    a. Input ac voltage tolerance of 208 V, plus or minus 5 percent.
    b. Input-frequency tolerance of 06/11 Hz, plus or minus 6 percent.
    c. Minimum Efficiency: 96 percent at 60 Hz, full load.
    d. Minimum Displacement Primary-Side Power Factor: 96 percent.
    e. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
    f. Starting Torque: 100 percent of rated torque or as indicated.
    g. Speed Regulation: Plus or minus 1 percent.

4. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
5. Internal Adjustability Capabilities:

    a. Minimum Speed: 5 to 25 percent of maximum rpm.
    b. Maximum Speed: 80 to 100 percent of maximum rpm.
    c. Acceleration: 2 seconds to a minimum of 22 seconds.
    d. Deceleration: 2 seconds to a minimum of 22 seconds.
    e. Current Limit: 50 percent to a minimum of 110 percent of maximum rating.

6. Self-Protection and Reliability Features:

    a. Input transient protection by means of surge suppressors.
    b. Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
    c. Adjustable motor overload relays capable of NEMA ICS 2, Class 10 Class 20 Class 30 performance.
    d. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
    e. Instantaneous line-to-line and line-to-ground overcurrent trips.
    f. Loss-of-phase protection.
    g. Reverse-phase protection.
    h. Short-circuit protection.
    i. Motor overtemperature fault.

7. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads, spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
8. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.
9. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
10. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back, based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
11. Door-mounted, digital status lights shall indicate the following conditions:

    a. Power on.
    b. Run.
    c. Overvoltage.

d. Line fault.
e. Overcurrent.
f. External fault.

12. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed-time meter.
13. Meters or digital readout devices and selector switch, mounted flush in controller door and connected, to indicate the following controller parameters:

    a. Output frequency (Hertz).
    b. Motor speed (rpm).
    c. Motor status (running, stop, fault).
    d. Motor current (amperes).
    e. Motor torque (percent).
    f. Fault or alarming status (code).
    g. Proportional-integral-derivative feedback signal (percent).
    h. DC-link voltage (volts dc).
    i. Set-point frequency (Hertz).
    j. Motor output voltage (volts).

14. Control Signal Interface:

    a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
    b. Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:

        1) 0 to 10-V dc.
        2) 0-20 or 4-20 mA.
        3) Potentiometer using up/down digital inputs.
        4) Fixed frequencies using digital inputs.
        5) RS485.
        6) Keypad display for local hand operation.

    c. Output signal interface with a minimum of one analog output signal (0/4-20 mA), which can be programmed to any of the following:

        1) Output frequency (Hertz).
        2) Output current (load).
        3) DC-link voltage (volts dc).
        4) Motor torque (percent).
        5) Motor speed (rpm).
        6) Set-point frequency (Hertz).

    d. Remote indication interface with a minimum of two dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

        1) Motor running.
        2) Set-point speed reached.
        3) Fault and warning indication (overtemperature or overcurrent).
        4) High- or low-speed limits reached.

15. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
16. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker NEMA AB 1, molded-case switch NEMA KS 1, nonfusible switch NEMA KS 1, fusible switch with lockable handle.
17. Accessories:

    a. Devices shall be factory installed in controller enclosure unless otherwise indicated.
    b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
    c. Standard Displays:

        1) Output frequency (Hertz).
        2) Set-point frequency (Hertz).
        3) Motor current (amperes).
        4) DC-link voltage (volts dc).
        5) Motor torque (percent).
        6) Motor speed (rpm).
        7) Motor output voltage (volts).

2.4 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.
    b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Charge: R-410A.
    d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F.
7. Mounting Base: Polyethylene.

2.5 OUTDOOR UNITS (6 TONS OR MORE)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.
    b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Charge: R-410A.
    d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F.
7. Mounting Base: Polyethylene.

2.6 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

G. Additional Monitoring:

1. Monitor constant and variable motor loads.
2. Monitor variable-frequency-drive operation.
3. Monitor economizer cycle.
4. Monitor cooling load.
5. Monitor air distribution static pressure and ventilation air volumes.

2.7 CAPACITIES AND CHARACTERISTICS: See Contract Drawings

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations.
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

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

1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
2. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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

3.5 DEMONSTRATION

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

END OF SECTION 238126

Section 238219
Fan Coil Units

CAf H5 PRT1 Tf AL

5-5 f TLAHTG GE Vc N T1 HS

A- GraDings and general provisions oO tUe VontraM. inMluding Reneral and Supplementary Vonditions and Givision w5 SpeMCMation SeMtions. apply to tUis SeMtion-

5-2 Sc N NAf h

A- SeMtion YnMludesI
5- GuMted Can Moil units and aMessories-

5-3 AVHYE1 Sc BN YHHALS

A- CroduM Gatal 8or eaMU type oCproduM-

5- YnMude rated MapaMties. operating MUaraMeristiMs. and CurnisUed speMalties and aMessories-

B- LTTG SubmittalsI

5- CroduM Gata Cor Vredit TA : I GoMumentation indiMating tUat e6uipment and reCigerants Momply-
2- CroduM Gata Cor Crere6uisite YT7 5I GoMumentation indiMating tUat units Momply DitU AS9f AT q2-5. SeMtion F P8Systems and T6uipment-&

V- SUop GraDingsI

5- YnMude details oOe6uipment assemblies- YndiMate dimensions. DeigUts. loads. re6uired MlearanMes. metUod oCCeld assembly. Momponents. and loMation and si(e oCeaMU Celd MonneMion-
2- YnMude diagrams Cor poDer. signal. and Montrol Diring-

G- Samples Cor Ynitial SeleMtionI 8or units DitU CaMoryPapplied Molor CnisUes-

T- Samples Cor) eriCMationI 8or eaMU type oCCan Moil unit indiMated-

5-: Yl 8Ef NAHYE1 AL Sc BN YHHALS

A- Voordination GraDingsI 8loor plans. reCeMed Meiling plans. and otUer details. draDn to sMale. on DUiMU tUe CollOding items are sUoDn and Moordinated DitU eaMU otUer. based on input Ccom installers oCtUe items involvedI

5- Suspended Meiling Momponents-
2- StruMural members to DUiMU Can Moil units Dill be attaMUed-

3- NetUod oOattaMUing Uangers to building struMure-
: - Si(e and loMation oOinitial aMMess modules Oor aMoustiMal tile-
F- Ytems penetrating OnisUed Meiling. inMluding tUe OolloDingI

a- LigUting O, tures-
b- Air outlets and inlets-
M- Speazers-
d- Sprinzlers-
e- AMMess panels-

B- SeismiM7 ualiOMation VertiOMatesI 8or Oan Moil units. aMMessories. and Momponents. Orom manuOaMturer-

5- Basis Oor VertiOMationI YndiMate DUetUer DitUstand MertiOMation is based on aMtual test oOassembled Momponents or on MalMulation-
2- Gimensioned Eutline GraDings oOT6uipment c nitI YdentiOy Menter oOgravity and loMate and desMribe mounting and anMUorage provisions-
3- Getailed desMription oOe6uipment anMUorage deviMes on DUiMU tUe MertiOMation is based and tUeir installation re6uirements-

V- 8ield 6ualityRMontrol reports-

G- Sample j arrantyI 8or speMial Darranty-

5-F VLESTE c H Sc BNYHHALS

A- Eperation and NaintenanMe GataI 8or Oan Moil units to inMlude in emergenMy. operation. and maintenanMe manuals-

5- Yn addition to items speMiOied in SeMtion w5k023 &Eperation and NaintenanMe Gata.& inMlude tUe OolloDingI

a- NaintenanMe sMUedules and repair part lists Oor motors. Moils. integral Montrols. and Oilters-

5-q NAYl HT1 A1 VT NAHTf YAL Sc BNYHHALS

A- 8urnisU e, tra materials tUat matMU produMts installed and tUat are paMzaged DitU proteMtive Movering Oor storage and identiOied DitU labels desMribing Montents-

5- 8an Voil c nit 8iltersI 8urnisU Ene spare Oilters Oor eaMU Oilter installed-

5-k 7 c ALYHh ASSc f A1 VT

A- Vomply DitU 1 8CA kw-

B- AS9 f AT VomplianMeI ippliMable re6uirements in AS9 f AT q2-5. SeMtion F P&Systems and T6uipment& and SeMtion k P&VonstruMtion and Startup-&

V- AS9f ATWTS 4w-5 VomplianMel AppliMable re6uirements in AS9f ATWTS 4w-5. SeMion q P &9eating.) entilating. and AirPVonditioning-&

5-0 VEEf GY1AHYE1

A- Voordinate layout and installation oOQan Mbil units and suspension system Momponents DitU otUer MonstruMtion tUat penetrates or is supported by Meilings. inMuding ligUt Q,tures. 9) AV e6uipment. OrePsuppressionPsystem Momponents. and partition assemblies-

5-4 j Af f A1Hh

A- SpeMal j arrantyI NanuQaMurer agrees to repair or replaMe Momponents oOMondensing units tUat Qail in materials or DorzmansUip DitUin speMQed Darranty period-

5- 8ailures inMude. but are not limited to. tUe QolloDingI

a- Vompressor Qailure-
b- Vondenser Mbil leaz-

2- j arranty CeriodI 8our years Qom date oOSubstantial Vompletion-
3- j arranty Ceriod xVompressor EnlyQ. 8ive years Qom date oOSubstantial Vompletion-

CAf H2PCf EGc VHS

2-5 ShSHTN GTSVf YCHYE1

A- TleMriMal Vomponents. GeviMes. and AMMessoriesI Listed and labeled as deQned in 18CA kw. by a 6ualiQed testing agenMy. and marzed Qor intended loMation and appliMation-

B- 8aMoryPpaMzaged and Ptested units Qor) f 8 systems rated aMMording to A9f Y:: w. AS9f AT 33. and c L 544F-

2-2 Gc VHTG 8A1 VEYL c 1YHS

A- NanuQaMurersI Sub/eMt to MomplianMe DitU re6uirements. provide produMts by one oOtUe QolloDing or approved e6uall

5- Varrier Vorporation" a unit oOc nited HeMUnologies Vorp-

2- Gaizin
3- Gf S Narlo Voil" part oOGf S HeMUnologies. YnM-
:- GunUamPBusU-
F- Tngineered Air-
q- T1) Yf EPHTV" by ; oUnson Vontrols. YnM-
k- 8irst Vompany CroduMts-
0- RreenUeMz 8an Vorporation-
4- YTV xYnternational Tnvironmental VorporationQLSB Ynustries-
5w- 1ailor Ynustries YnM-
55- f oseme, CroduMts-

52- Superior f e, -
53- Hitus-
5: - Hrane YnM-
5F- c SA Voil X Air-

B- 8an Voil c nit VonQgurations-

5- 1umber oOVoilsI Ene Or Ueating and Mooling. MonneMted to) f 8 systems and outdoor air MonneMted to Tf c systems-

V- Voil SeMtion YnsulationI 5\2PmMUP5PmMUPUiVz. Mbated OilPaMed glass Ober Momplying DitU ASHN V 5wk5 and attaMUed DitU adUesive Momplying DitU ASHN V 45q-

5- SurQaMePBurning VUaraMteristiMsI Ynsulation and adUesive sUall Uave a Mombined ma, imum QameP spread inde, oO2F and smozePdeveloped inde, oOFw DUen tested aMMording to ASHN T 0: by a 6ualiQed testing agenMy-
2- Airstream SurQaMesI SurQaMes in MontaM DitU tUe airstream sUall Momply DitU re6uirements in AS9 f AT q2-5-

G- Nain and Au, iliary Grain CansI ClastiMStainless steel Ynsulated galvani(ed steel DitU plastiMliner- 8abriMate pans and drain MonneMtions to Momply DitU AS9 f AT q2-5-

T- VUassisI Ralvani(ed steel DUere e, posed to moisture. DitU bazedPenamel OnisU and removable aMMess panel. DitU poDderPMoat OnisU and removable aMMess panel-

8- VabinetsI Steel DitU bazedPenamel OnisU in manuQaMurer.s standard paint Molor-

R- 8iltersI Ninimum arrestanMe and a minimum eQOMenMy reporting value xNTf) QaMMording to AS9 f AT F2-2 and all addendums-

9- NTf) f atingI 0 DUen tested aMMording to AS9 f AT F2-2-

Y- Yndoor f eOigerant VoilsI Vopper tube. DitU meMUaniMally bonded aluminum Ons spaMed no Mloser tUan w-5 inMU and bra(ed /oints at Ottings- Vomply DitU A9 f Y25wW: w. and leaz test to minimum : Fw psig Or a minimum 3wwP psig Dorzing pressure- YnMude tUermal e, pansion valve. Moils MonneMted to) f 8 systems-

; - GireMPGriven 8ansI Gouble DidtU. OrDard Murved. MentriQgal" DitU permanently lubriMated. TVN motor resiliently mounted in tUe Oan inlet- Aluminum or paintedPsteel DUeels. and paintedPsteel or galvani(edPsteel Oan sMolls-

K- f emote Mondensing units are speMQed in SeMtion 23q2ww &CaMzaged Vompressor and Vondenser c nits& Or) f 8 systems-

L- VontroI deviMes and operational se6uenMe are speMQed in SeMtion 23wF: 0 &) ibration and SeismiMVontrols Or 9) AV Ciping and T6uipment-&

N- BasiMc nit VontroIsI

5- Vontrol voltage transOrmer-
2- j allPmounting tUermostat DitU tUe OolloDing Oeatures-

a- 9eatPMoolPoQOsDitMU-
b- 8an onPauto sDitMU-

M- 8anPspeed sDitMU-
d- Nanual AutomatiMMUangeover-
e- Ad/ustable deadband-
O- VonMealed set point-
g- VonMealed indiMation-
U- Gegree 8 indiMation-

3- j allPmounting Uumidistat-

a- VonMealed set point-
b- VonMealed indiMation-

: - j allPmounting temperature sensor-
F- c noMMupiedPperiodPoverride pusU button-
q- Gata entry and aMMess port-

a- Ynput data inMudes room temperature. and Uumidity set points and oMMupied and unoMMupied periods-
b- Eutput data inMudes room temperature and Uumidity. supplyPair temperature. enteringPDater temperature. operating mode. and status-

1- GGV Herminal VontrollerI

5- SMUeduled EperationI EMMupied and unoMMupied periods on sevenPday MoMz DitU a minimum oOOour programmable periods per day-
2- c noMMupiedPCeriodPEverride EperationI HDo Uours-
3- c nit SupplyPAir 8an EperationI

a- EMMupied CeriodsI 8an runs Montinuously-
b- c noMMupied CeriodsI 8an MyMes to maintain room setbaMz temperature-

: - f eOigerantPVoil EperationI

a- EMMupied CeriodsI Start Mompressor to maintain room temperature or Uumidistat set point-
b- c noMMupied CeriodsI Stop Mompressor Mooling and MyMe Mompressor Oor Ueating to maintain setbaMz temperature-
M- EMMupied and unoMMupied sMUedules-

E- TleMriMal VonneMionI 8aMory Dire motors and Montrols Oor a single eleMriMal MonneMion-

C- VapaMities and VUaraMeristiMsI See VontraMI GraDings

CAf H3 PT' TVc HYE1

3-5 T' ANYI AHYE1

A- T, amine areas. DitU Ynstaller present. to reMeive Oan Moil units Oor MomplianMe DitU re6uirements Oor installation toleranMes and otUer Monditions aOeMing perOormanMe oOtUe j orz-

B- T, amine rougUingPn Oor piping and eleMriMal MonneMions to veriO aMual loMations beOore Oan Moil unit installation-

V- CroMeed DitU installation only aCter unsatisGaMory Monditions Uave been MorreMted-

3-2 YI SHALLAHYE1

A- Ynstall Gan Mbil units level and plumb-

B- Ynstall Gan Mbil units to Momply DitU 18CA 4wA-

V- Suspend Gan Mbil units Gom struMure DitU elastomeriM Uangers-) ibration isolators are speMGed in SeMion 23wF: 0 &) ibration and SeismiMVontrols Gor 9) AV Ciping and T6uipment-&

G-) eriGy loMations oCtUermostats. Uumidistats. and otUer e, posed Montrol sensors DitU GraDings and room details beGore installation- Ynstall deviMes : 0 inMUes above GnisUed Gloor-

3-3 VE11TVHYE1S

A- Ciping installation re6uirements are speMGed in otUer SeMions- GraDings indiMate general arrangement oO piping. Gttings. and speMalties- SpeMGMMonneMion re6uirements are as GolloDsI

5- Ynstall piping ad/aMent to maMUine to alloD serviMe and maintenanMe-
2- VonneM piping to Gan Mbil unit GaMory piping paMzage- Ynstall piping paMzage iOsUipped loose-
3- VonneM Mondensate drain to plenum rated Mondensate pump as sUoDn on VontraM GraDings-

a- Ynstall Mondensate trap oCade6uate deptUto seal against Gan pressure- Ynstall MeanoutsinpipingatMUanges oCdireMion-

B- VonneM supplyPair returnPair and outdoor air duMs to Gan Mbil units DitU Ge, ible duM MonneMors speMGed in SeMion 2333ww&Air GuM AMessories-&Vomply DitUsaGty re6uirements in c L 544F Gor duM MonneMions-

V- Rround e6uipment aMMording to SeMion 2qwF2q &Rrounding and Bonding Gor TleMriMal Systems-&

G- VonneM Diring aMMording to SeMion 2qwF54 &LoDP) oltage TleMriMal CoDer VonduMors and Vables-&

3-: 8YTLG7cALYHh VE1HfEL

A- Hesting AgenMyI Tngage a 6ualiGed testing agenMy to perGorm tests and inspeMions-

B- NanuGaMurerJs 8ield ServiMeI Tngage a GaMoryPautUori(ed serviMe representative to test and inspeM Momponents. assemblies. and e6uipment installations. inMluding MonneMions-

V- CerGorm tUe GollDing tests and inspeMions DitU tUe assistanMe oCa GaMoryPautUori(ed serviMe representativeI

5- EperationalHestIAGer eleMriMal MrMuitry Uas been energi(ed. start units to MonGrm proper motor rotation and unit operation-

2- E perate eleMriM Ueating elements tUrougU eaMU stage to veriQ proper operation and eleMriMal MonneMtions-

3- Hest and ad/ust Montrols and saQety deviMes- f eplaMe damaged and malQunMtioning Montrols and e6uipment-

G- f emove and replaMe malQunMtioning units and retest as speMQed above-

T- Crepare test and inspeMtion reports-

3-F AG; c SHYl R

A- Ad/ust initial temperature and Uumidity set points-

B- E MMupanMy Ad/ustments I j Uen re6uested DitUin 52 montUs oQdate oQSubstantial Vompletion. provide onPsite assistanMe in ad/usting system to suit aMual oMMupied Monditions- Crovide up to tDo visits to Cro/eM during otUerPtUanPnormal oMMupanMy Uours Qor tUis purpose-

3-q GTNE1 SHf AHYE1

A- Tngage a QaMoryPautUori(ed serviMe representative to train EDnerJs maintenanMe personnel to ad/ust. operate. and maintain Qan Mbil units-

T1 G E8 STVHYE1 230254

Section 260500
Common Work Results For Electrical

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. The Subcontractor shall furnish services, skilled and common labor, and apparatus and materials required for the complete installation as shown and within the intent of the drawings and these Specifications.
   2. Work includes, but not limited to, the following and shall be completed in accordance with the project construction drawings and specifications:
      a. Installation of transformer, and cable/conduit from the existing service and to the electrical room of the new addition.
      b. Installation of all lighting, devices, wiring, conduit, disconnects, distribution, etc. in the new addition, including supply to all HVAC and mechanical equipment.
      c. Removal/relocation of existing feeds to window air conditioners and existing fan coil units, to supply new fan coil units with integral compressors.
      d. Relocation and/or addition of power and lighting to renovated sections of the existing building.
      e. Installation of additional devices and circuits to renovated labs and classrooms.

C. Related Sections:
   1. This section applies to Division 26 Sections.

1.2 REFERENCES

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

B. ANSI/NFPA 70 - National Electrical Code.

C. ANSI - American National Standards Institute

D. Illuminating Engineering Society of North America (IES)

E. National Electrical Safety Code (NESC)

F. NFPA 70E- Standard for Electrical Safety in the Workplace

G. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, latest edition.

1.3 SUBMITTALS

A. Shop Drawings: The Subcontractor shall submit for approval Shop Drawings prepared in accordance with Drawings and sections of the Specifications.

1.4 QUALITY ASSURANCE

A. If the Drawings or Specifications may not appear clear or definite, the Subcontractor shall request the Project Manager through 'Request for Information' (RFI) process for an interpretation and decision of same and shall have such questions decided before proceeding with the Work.

B. Manufacturer's Directions: Follow manufacturer's directions covering points not shown on the drawings or specified herein. Manufacturer's directions do not take precedence over drawings and Specifications. Where these are in conflict with the Drawings and Specifications, notify the Project Manager for clarification before installing the work.

C. Protection of Equipment:
   1. Care shall be exercised during construction to avoid damage or disfigurement. Equipment shall be protected from dust and moisture prior to and during construction. The Subcontractor is cautioned that concrete finishing, painting, etc. in electrical rooms shall not proceed if unprotected equipment is installed.
   2. Where required or directed, construct temporary protection for equipment and installations so as to protect same from dust and debris caused by construction.
   3. All protection shall be substantially constructed with the use of clean canvas, heavy plastic, and/or plywood as required, and made rain tight and/or dust resistant as directed or appropriate for conditions.
   4. The Subcontractor shall repair by spray or brush painting, after properly preparing the surface, scratches or defects in the finish of the equipment. Only identical paint furnished by the equipment manufacturer shall be used for such purposes.
   5. Failure of the Subcontractor to protect the equipment as outlined herein shall be grounds for rejection of the equipment and its installation.

D. Removed Equipment and Material: Coordinate removal of the materials and debris with the project construction officer - Owner owned Materials to be turned over to Owner.

E. Shutdown: Provide request to the owner representative to shut down the power to any equipment to be removed. The request shall be submitted not less than 5 working days before scheduled work. The power shall not be shut down to any equipment for which the approval was not obtained.

F. Cleaning: All material shall be protected from dust and the construction debris. All material shall be cleaned before installation in accordance with manufacturer specification. Clean area of work after every working shift.

G. Qualifications and License Requirements:
   1. Prime, Sub, or Sub-Sub contractor performing electrical construction work on the project shall be Licensed in the state of Pennsylvania.
   2. Subcontractor performing electrical construction work shall provide details of the project experience addresses and references with names and phone numbers.
   3. Certified electricians shall have evidence of certification in their possession at all times. Non-certified personnel shall perform electrical work under the continuous supervision of a certified electrician.

H. Materials and Equipment: Materials and equipment shall be new. Materials and equipment for which tests have been established by Underwriter's Laboratories, Inc. shall be approved by that body and shall bear its label of approval or the label of an OSHA approved nationally recognized testing laboratory [NRTL].

1. All equipment shall comply with requirements of the applicable Underwriter's Laboratories, Inc. standards.
2. The materials to be furnished under this Specification shall be the standard products of manufacturers regularly engaged in the production of such equipment equal to or superior to material specified and shall be the manufacturer's latest standard design that complies with the Specification requirements.

I. Approval of Materials:
1. A complete list of materials and equipment proposed shall be submitted to the Project Manager for approval. The list shall include for each item: the manufacturer, the manufacturer's catalog number, type or class, the rating, capacity, size, etc.
2. The Subcontractor shall submit a brochure containing catalog cuts or drawings and data for every all equipment installed under this project.
3. Before installation of the equipment, the Subcontractor shall submit for approval detailed construction drawings for each item of fabricated equipment required for the electrical installation. Drawings shall be to scale and fully dimensioned and shall provide sufficient detail to clearly indicate the arrangement of equipment and its components.
4. Installation of approved substituted equipment is the Subcontractor's responsibility, and changes required to work included under other divisions for installations of approved substituted equipment must be made to the satisfaction of the Architect-Engineer and without change in contract price. Approval by the Architect-Engineer of substituted equipment and/or dimension drawings does not waive these requirements.

1.5 EXISTING CONDITIONS

A. The Subcontractor shall examine the site and become familiar with conditions that may affect the work covered by this division of the Specifications in order to obtain a conclusive bid. Failure to do so shall not lessen the subcontractor's responsibility or entitle him to additional compensation for work not included in the bid.

B. The electrical prime, sub or sub-sub contractor shall list separately in the bid quote exceptions taken from the construction documents and specifications. If none are specified in the bid quote, it shall be understood that the prime, sub or sub-sub contractor shall comply with the requirements of the construction documents and specifications in their entirety.

1.6 MAINTENANCE

A. Maintenance and Operating Instructions:
1. At time of occupancy, arrange for manufacturer's representatives to instruct building, operating and maintenance personnel in the use of equipment requiring operating and maintenance. Arrange for personnel to be instructed at one time. Pay the costs for such service.
2. Maintenance and Operation manuals and operating instructions shall be provided training agenda a minimum 5 days before training.

PART 2 - PRODUCTS

2.1 GENERAL

A. In addition to material and equipment specified, the Subcontractor shall also provide incidental materials required to effect a complete installation. Such incidental materials include solders, tapes, caulking, mastics, gaskets and similar items that are approved for the purpose.

B. Materials and equipment shall be uniform throughout the installation. Equipment of the same type shall be of the same manufacturer. Materials and equipment shall be new. Materials and equipment for which tests have been established by the Underwriter's Laboratories, Inc. shall bare a UL label.

PART 3 - EXECUTION

3.1 TESTS

A. Upon completion of the electrical construction work, perform tests and provide test reports as specified in this and other sections. Testing will include, but not limited, to:
   1. Verify no circuit is grounded or contains a short circuit
   2. All devices work smoothly and operate the equipment shown on the plans.
   3. No removable or openable cover is restricted by any other equipment whether electrical or installed under a different contract.
   4. All connections are tight and are not causing a high resistance connection.

B. Tests of equipment shall be made in accordance with the manufacturer recommendations. The application or interruption of power shall be programmed and directed by the Project Manager.

C. The Subcontractor shall submit to the Project Manager three (3) copies of test results, certified in writing, witnessed, signed and dated, immediately upon completion of work. Unsatisfactory condition revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be corrected by the Subcontractor to the satisfaction of the Project Manager.

D. The Project Manager reserves the right to require that the Subcontractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records of the Subcontractor at any time during the course of the work. The Subcontractor shall correct unsatisfactory portion of his work that is revealed by the tests or that may be due to progressive deterioration during this period, unless the item in question was a direct specification.

3.2 ARC FLASH HAZARD WARNING LABELING

A. Switchgear, switchboards, panelboards, industrial control panels, and meter panels/enclosures shall be labeled to warn qualified persons of potential electric shock.

B. Labels shall, as a minimum, display the following:
   1. Incident energy in Calories/cm2 at the working distance.
   2. Flash hazard boundary distance.
   3. Shock hazard voltage when covers are removed.
   4. Limited approach boundary.
   5. Restricted approach boundary.
   6. Prohibited approach boundary.

3.3 EQUIPMENT IDENTIFICATION

A. Transformers: Transformers shall be identified by one-inch-high white characters giving bank number and circuit feeding the transformer in agreement with the Drawings. Labeling may be black writing on white background applied sticker (emergency panels shall be a red background), or engraved nameplate with 1” high lettering, white letters on Black background.

B. Panelboards: Panelboards shall be identified with the name listed on the drawings and panel schedule by one-inch-high black writing on white background applied sticker (emergency panels shall be a red background). Voltage and phase shall be describe on Arc Flash label.

C. Schedules: Panelboards shall be furnished with a complete 8-1/2" x 11" typewritten schedule mounted on the inside of the inner door with a protective cover. If field changes are necessary, new schedules shall be provided by the Subcontractor. Forms will be provided by the Project Manager.

D. Receptacles and Light Switches: Receptacles and light switches shall be identified by a circuit number as indicated on the drawings with 1/4 inches (6 mm) high white characters on 1/2 inch (12 mm) wide dark contrasting stick-on embossing tape placed directly above the device on the reverse side of the cover.

E. Equipment: Properly identify circuit breakers and other devices on switchboards, motor disconnect switches, starters, time clocks, and other apparatus used for operation of, or control of circuits, appliances or equipment by means of 1” high lettering in black on white background applied sticker.

F. Conductors: The main incoming power will be delivered to the building site with the A phase, B phase, C phase and Neutral phase (if applicable) cables positively identified. The phase sequence rotation shall be A-B-C clockwise and standard left to right.
   1. Conductors shall be identified using factory colored wires or by using color bands or tape intended for the purpose and approved for wet, outdoor applications at terminations, junctions and wherever the conductors are accessible in pull boxes. Conductors shall be color coded, identified as "A Phase", "B Phase", and "C Phase".
   2. For color coding of low voltage conductors, see Division 26 Section "600 Volt Conductors and Cable", Paragraph 2.1.
   3. Branch circuit identification shall be by use of wrap-around labels such as manufactured by Brady, Thomas and Betts, or equal. Labels shall be placed on conductors at all loads not identified under other sections of this specification. This includes, but not limited, to: junction boxes, relays, disconnect switches, motor starters, and controls.

3.4 NOISE AND VIBRATION

A. The Subcontractor shall cooperate in reducing objectionable noise or vibration. If noise or vibration is a result of improper material or installation, these conditions shall be corrected at no cost to the Owner.

3.5 GENERAL INSTALLATION METHODS

A. Carpentry, Cutting, Patching, and Core Drilling:
   1. Provide carpentry, cutting, patching, and core drilling required for installation of material and equipment specified in the scope of work.
   2. Do not cut, core, or drill structural members without consent of the Project Manager.
   3. Seismic Mounting: Electrical material and equipment, including floor mounted equipment, suspended raceways and light fixtures, shall be installed with bracing, cabling, or anchoring to comply with the latest edition of the CBC and Standard and Division 01 Section “Lateral Force Provisions.” See 031500 – Concrete Accessories for approved anchors.

B. Waterproof Construction:
   1. Maintain waterproof integrity of penetrations of materials intended to be waterproof. Provide flashings at exterior roof penetrations. Caulk penetrations of foundation walls and floors watertight. Provide membrane clamps at penetrations of waterproof membranes.
   2. Provide waterproof NEMA 3R enclosures for equipment or devices mounted outside or otherwise exposed to the weather.
   3. Leave drip loop at all cable to conduit entry points, and penetrate building at an upward angle going into the building with any conduit penetrations.

C. Sleeves, Conduit Stubs, and Slab Penetrations: See Division 09 Section "Painting".

D. Painting of Electrical Equipment and Hardware:

1. Provide moisture resistant paint for exterior painting.
2. Colors shall be as shown on the drawings unless specified.
3. Refer to individual Sections and Construction Drawings for painting requirements of electrical equipment.

E. Equipment Concrete Pads:
1. Equipment located on concrete floors inside the building or on grade outside the building, shall be mounted on a concrete base. The concrete base shall be four inches high and shall extend four inches (4”) beyond the edge of equipment base unless indicated otherwise on drawings. All pads shall have 1” chamfered or rounded edge.

F. Demolition and Removal:
1. Refer to construction documents for demolition and removal details.
2. The approval shall be obtained from the owner representative/ construction manager prior to disposal of electrical equipment and materials.
3. Disconnected wiring shall be removed from raceway systems, panels, enclosures pull boxes, junction boxes etc. irrespective of whether the removal is specified in the construction documents or not. The empty raceway systems shall be tagged spare on both ends of each termination.
4. All removed products are considered property of the Owner and shall be turned over to their representative, or he shall provide direction of an alternative.

END OF SECTION 260500

Section 260519
Low-Voltage Electrical Power Conductors And Cables

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:
1. Section 260500 "Common Work Result for Electrical".
2. Section 260533 “Raceways and Boxes for Electrical Systems”
3. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. VFD: Variable Frequency Drive.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Alpha Wire Company.

2. Belden Inc.
3. Cooper Industries, Inc.
4. General Cable Technologies Corporation.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2

D. Multi-conductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type TC shielded with ground wire.

E. VFD Cable:

1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
2. Type TC-ER with oversized cross-linked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

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

1. 3M.
2. AFC Cable Systems; a part of Atkore International.
3. Gardner Bender.
4. Hubbell Power Systems, Inc.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, marked for intended location and application, and installed per the listed application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger. Aluminum cable may be substituted for circuits over 100A if ampacity of the alternate is equal to or greater than the design, and all terminations are crimp-on then bolted to device terminal.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN/THWN-2, single circuits in metallic raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single circuits in metallic raceway and Metal-clad assembled cable.

C. Feeders in Cable Tray: Type TC-ER

D. Exposed Branch Circuits: Type THHN/THWN-2, single circuits in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single circuits in metallic raceway and Metal-clad cable, Type MC.

F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables/conduits parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible. Flexible metallic conduit, in lengths not exceeding 4', may be used to offset or go around structural blockages.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

2. Use crimp terminals with bolted lugs for each permitted use of Aluminum wire.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

D. Receptacles shall be side wired per Exhibit 110.3 of NEC Handbook.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

C. Identify each spare conduit with a tag listing size and number of bends. Attach tag to both the pull string and anchor inside box or at stub-up. Tags exposed to elements shall be waterproof and non-degrading with permanent markings

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

B. Firestopping shall be intumescent caulk/putty listed for use and installed in quantity required to maintain wall rating.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductors and conductors feeding all other supplemental and supporting equipment for compliance with project requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 8 AWG and larger. Immediately before scan (not sooner), remove box and equipment covers so splices are accessible to portable scanner. All tested circuits shall be operating under full load for a minimum of 10 minutes prior to testing. Any splice showing a temperature rise of 10 degrees Centigrade over ambient will be considered deficient. Correct deficiencies determined during the scan at no cost to owner.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 1 month after failed initial inspection. Any second failures shall be pointed out to the owner and the offending equipment replaced at no cost to the owner.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

B. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

Section 260526
Grounding And Bonding For Electrical Systems

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

C. Field quality-control reports.

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

E. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. Galvan Industries, Inc.; Electrical Products Division, LLC.
3. Harger Lightning & Grounding.
4. O-Z/Gedney; a brand of Emerson Industrial Automation.

2.2 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare copper conductors, solid if #8 and smaller, stranded if larger. Aluminum shall not be used for grounding electrode conductors or at/below grade but may be used for grounding feeders or branch circuits if terminated as described in Low-Voltage Electrical Power Conductors and phase conductors are Aluminum.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.

B. Grounding Conductors: Green-colored insulation.

C. Conductor Terminations and Connections:
   1. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Transformer: Connect grounding terminal to the equipment ground at the transformer location. The conductor shall be connected to the equipment grounding conductor terminal and to the frame of the transformer.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

3.4 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

C. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

D. Bond all other metallic systems, such as gas piping and sprinkler piping as required in NFPA 70, National Electrical Code

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Excessive Ground Resistance: If resistance to ground exceeds 20 Ohms, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

Section 260529
Hangers And Supports For Electrical Systems

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Hangers.
b. Steel slotted support systems.
c. Trapeze hangers.
d. Clamps.
e. Turnbuckles.
f. Sockets.
g. Eye nuts.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Equipment supports.

4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Structural members to which hangers and supports will be attached.

B. Seismic Qualification Certificates: For hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

   1. AWS D1.1/D1.1M.
   2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

   1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
   2. Component Importance Factor: 1.5.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

   1. Flame Rating: Class 1.
   2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:
   a. B-line, an Eaton business.
   b. Flex-Strut Inc.
   c. GS Metals Corp.
   d. G-Strut.
   e. Haydon Corporation.
   f. Metal Ties Innovation.
   g. Thomas & Betts Corporation, A Member of the ABB Group.

2. Material: Galvanized steel.

3. Channel Width: 1-1/4 inches (31.75 mm)
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
6. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel for use in hardened Portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

1) B-line, an Eaton business.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti, Inc.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/2 inch (12 mm) in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69 and/or Spring-tension clamps].
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

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

END OF SECTION 260529

Section 260533
Raceways And Boxes For Electrical Systems

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EO Struhtural members in pat: s oThonduit groups Pit: hommon supportsO
2O F" Aw and plumbing items and arh: itehtural Teatures in pat: s oT honduit groups Pit: hommon supportsO

BO QualiThation Cata8Vor proTessional engineerO

wO Seismih QualiThation wertiThates8Vor enhlosures4habinets4and honduit rahxs and t: eir mounting provisions inhluding t: ose Tor internal homponents4Trom manuTahturerO

EO Basis Tor wertiThation8 7ndihate P: et: er Pit: stand hertiThation is based on ahtual test oT assembled homponents or on halhulationO
2O Cimensioned Uutline CraPings oT1 l uipment f nit87dentiTy henter oTgravity and lohate and deshribe mounting and anh: orage provisionsO
cO Cetailed deshription oTel uipment anh: orage devihes on P: ih: t: e hertiThation is based and t: eir installation rel uirementsO
9O Cetailed deshription oT honduit support devihes and interhonnehtions on P: ih: t: e hertiThation is based and t: eir installation rel uirementsO

CO Sourhe l ualityNhontrol reportsO

- AMG2 N- MUCf wGS

20E Y 1GAL wUDCf 7GS4Gf B7D. 4ADC V7GG7D. S

AO YanuTahturers8 Subzeht to homplianhe Pit: rel uirements4 provide produhts by one oT t: e TolloPing4or approved el ual8

EO AVw wable Systemska part oTAtxore 7nternationalO
2O Anamet 1lehtrihal47nhO
cO 1lehtriNVleRwompanyO
9O UNHJ edneyka brand oT1merson 7ndustrial AutomationO
5O - atriot Aluminum - roduhts4LLwO
3O Mepublih wonduitO
qO Mobroy 7ndustriesO
j O Sout: Pire wompanyO

/ O G: omas ; Betts worporation4A Y ember oTt: e ABB . roupO

BO Listing and Labeling8Y etal honduits4tubing4and Tittings s: all be listed and labeled as deTned in DV- A q04by a I ualiTed testing agenhy4and marxed Tor intended lohation and applihationO

wO . Mw8womply Pit: ADS7wj 0CE and f L 3O

CO AMw8womply Pit: ADS7wj 0C5 and f L 3AO

1O 7Y w8womply Pit: ADS7wj 0C3 and f L E292O

VO - " wNwoated Steel wonduit8- " wNhoated rigid steel honduit or 7Y wO

EO womply Pit: D1Y A MD EO
2O woating G: ihxness800090 inh: ZE mm&4minimumO

. O 1Y G8womply Pit: ADS7wj 0C2 and f L q/ qO

FO VY w8womply Pit: f L EkVihhNhoated steel

7O LVY w8VleRible steel honduit Pit: - " w zahxet and homplying Pit: f L c30O

)O Vittings Tor Y etal wonduit8womply Pit: D1Y A VB E and f L 5E9BO

EO wonduit Vittings Tor F aWardous ZwlassiTed&Lohations8womply Pit: f L j j 3 and DV- A q0O
2O Vittings Tor 1Y G8

aO Y aterial8Steel
bO Gype8hompressionO

cO 1Rpansion Vittings8- " w or steel to math: honduit type4homplying Pit: f L 35E4rated Tor environmental honditions P: ere installed4and inhluding TeRible eRternal bonding zumperO
9O woating Tor Vittings Tor - " wNwoated wonduit8Y inimum t: ihxness oT0090 inh: ZE mm&4Pit: overlapping sleeves protehting t: readed zointsO

KO)oint wompound Tor 7Y w4 . Mw4or AMw8Approved4as deTned in DV- A q04by aut: orities : aving zurisdihtion Tor use in honduit assemblies4 and hompounded Tor use to lubrihate and proteht t: readed honduit zoints Trom horrosion and to en: anhe t: eir honduhtivityO

2Q2 Y 1GAL ' 7M1 ' A6S ADC Af (7L7AM6 . f GG1MS

AO Y anuTahturers8 Subzeht to homplianhe Pit: rel uirements4 provide produhts by one oT t: e TollоPing4or approved el ual8

EO BNline4an 1aton businessO
2O F oTmanka brand oT- entair 1l uipment - rotehtionO

BO Ceshription8 S: eet metal4homplying Pit: f L j q0 and D1Y A 2504 Gype E and Gype E2 P: ere rel uired4unless ot: erPise indihated4and siWed ahhording to DV- A q0O

EO Y etal PirePays installed outdoors s: all be listed and labeled as deTned in DV- A q04by a I ualiTed testing agenhy4and marxed Tor intended lohation and applihationO

wO Vittings and Ahhessories8 7nhlude hovers4 houplings4 oTsets4 elboPs4 eRpansion zoints4 adapters4 : oldNdoPn straps4 end haps4 and ot: er Tittings to math: and mate Pit: PirePays as reI uired Tor homplete systemO

CO ' irePay wovers8 VlangedNandNgasxeted type unless ot: erPise indihatedO

1O Vinis: 8Y anuTahturerXs standard enamel Tinis: O

20c Sf MVAw1 MAw1' A6S

AO Listing and Labeling8 SurTahe rahePays and teleNboPer poles s: all be listed and labeled as deTined in DV- A q04 by a I ualiTed testing agenhy4 and marxed Tor intended lohation and applihationO

BO SurTahe Y etal MahePays8. alvaniWed steel Pit: snapNon hovers homplying Pit: f L 5O

EO Y anuTahturers8 Subzeht to homplianhe Pit: reI uirements4 provide produhts by one oTt: e ToIloPing4 or approved eI ual8

aO Fubbell 7nhorporatedk' iring CevihenKellemsO
bO Y onoSystems47nhO

209 BU(1S41 DwLUSf M1S4ADC wAB7D1GS

AO Y anuTahturers8 Subzeht to homplianhe Pit: reI uirements4 provide produhts by one oTt: e ToIloPing4 or approved eI ual8
EO wrouseNFinds4 an 1aton businessO
2O 1. SJAppleton 1lehtrihO
cO 1rihxson 1lehtrihal 1I uipment wompanyO
9O VSM 7nhO
5O FoTmanka brand oT- entair 1I uipment - rotehtionO
3O Fubbell 7nhorporatedO
qO Y ilbanx Y anuTahturing woO
j O Y onoSystems47nhO
/ O UIdhastle 1nhlosure SolutionsO
E0O UNHJ edneyka brand oT1merson 7ndustrial AutomationO
EEO MAwUkFubbellO
E2O Mobroy 7ndustriesO
EcO Spring wity 1lehtrihal Y anuTahturing wompanyO

BO . eneral MeI uirements Tor BoRes4 1nhlosures4 and wabinets8 BoRes4 enhlosures4 and habinets installed in Pet lohations s: all be listed Tor use in Pet lohationsO

wO S: eet Y etal Uutlet and Cevihe BoRes8 womply Pit: D1Y A US E and f L 5E9AO

CO wastNY etal Uutlet and Cevihe BoRes8 womply Pit: D1Y A VB E4 Terrous alloy Gype VC4 Pit: gasxeted hoverO

1O Donmetallih Uutlet and Cevihe BoRes8 womply Pit: D1Y A US 2 and f L 5E9wO

VO Luminaire Uutlet BoRes8Donadzustable4designed Tor attah: ment oTluminaire Peig: ing 50 lb Z2c xg&OUutlet boRes designed Tor attah: ment oTluminaires Peig: ing more t: an 50 lb Z2c xg&s: all be listed and marxed Tor t: e maRmum alloPable Peig: tO

. O - addle Van Uutlet BoRes8Donadzustable4designed Tor attah: ment oTpaddle Tan Peig: ing q0 lb Zc2 xg&O

EO Listing and Labeling8 - addle Tan outlet boRes s: all be listed and labeled as deTned in DV- A q04by a I ualiTed testing agenhy4and marxed Tor intended lohation and applihationO

FO Small S: eet Y etal - ull and) unhtion BoRes8D1Y A US EO

7O BoR eRtensions used to ahhommodate neP building Tnis: es s: all be oT same material as rehessed boRO

)O Cevihe BoRCimensions89 inh: es sI uare by 2NEJ inh: es deep ZE00 mm sI uare by 30 mm deep& and 9 inh: es by 2NEJ inh: es by 2NEJ inh: es deep ZE00 mm by 30 mm by 30 mm deep&

KO . angable boRes are pro: ibitedO

LO FingedNwover 1nhlosures8 womply Pit: f L 50 and D1Y A 2504 Gype E and Gype E2 P: ere reI uired Pit: hontinuousNinge hover Pit: Tus: lath: unless ot: erPise indihatedO

EO Y etal 1nhlosures8Steel4Tnis: ed inside and out Pit: manuTahturerXs standard enamelO
2O 7nterior - anels8Steelkall sides Tnis: ed Pit: manuTahturerXs standard enamelO

YO wabinets8

EO D1Y A 2504 Gype Eand Gype E2 P: ere reI uired galvaniWedNsteel boR Pit: removable interior panel and removable Tront4 Tnis: ed inside and out Pit: manuTahturerXs standard enamelO
2O Finged door in Tront hover Pit: Tus: lath: and honhealed : ingeO
cO Key lath: to math: panelboardsO
9O Y etal barriers to separate Piring oTdiTerent systems and voltageO
5O Ahhessory Teet P: ere reI uired Tor Treestanding eI uipmentO
3O Donmetallih habinets s: all be listed and labeled as deTned in DV- A q04 by a I ualiTed testing agenhy4and marxed Tor intended lohation and applihationO

- AMGc N1(1wf G7UD

cOE MAw1' A6 A- - L7wAG7UD

AO 7ndoors8Apply rahePay produhts as spehiTed beloP unless ot: erPise indihated8

EO 1RposedDot Subzeht to - : ysihal Camage81Y GPit: hompression TttingsO
2O 1Rposed and Subzeht to Severe - : ysihal Camage8. MwOMahePay lohations inhlude t: e TollоPing8
aO Y eh: anihal roomsO

cO wonhealed in weilings and 7nterior ' alls and - artitions81Y GPit: hompression TttingsO

9O wonnehtion to " ibrating 1l uipment Zhnluding GransTormers and Fydraulih4 - neumatih4 1lehtrih Solenoid4 or Y otorNCriven 1l uipment&8 VY w4 eRhept use LVY w in damp or Pet lohationsO

5O Camp or ' et Lohations8. Mw or 7Y wO

3O BoRes and 1nhlosures8D1Y A 2504Gype E4Gype E2 P: ere reI uiredO

BO Y inimum MahePay SiWe8cJ9Nnh: Z2ENmm&trade siWeO

wO MahePay Vittings8wompatible Pit: rahePays and suitable Tor use and lohationO

EO Migid and 7ntermediate Steel wonduit8 f se t: readed rigid steel honduit Tittings unless ot: erPise indihatedOwomply Pit: D1Y A VB 20E0O

2O - " w 1Rternally woated4 Migid Steel wonduits8f se only Tittings listed Tor use Pit: t: is type oT honduitO- ath: and seal all zoints4 nihxs4 and shrapes in - " w hoating aTter installing honduits and TittingsOf se sealants rehommended by Titting manuTahturer and apply in t: ihxness and number oThoats rehommended by manuTahturerO

cO 1Y G8f se hompression TittingsOwomply Pit: D1Y A VB 20E0O

9O VleRible wonduit8 f se only Tittings listed Tor use Pit: TeRible honduitO womply Pit: D1Y A VB 2020O

CO 7nstall nonTerrous honduit or tubing Tor hirhuits operating above 30 FWO : ere aluminum rahePays are installed Tor suh: hirhuits and pass t: roug: honhrete4install in nonmetallih sleeveO

1O Co not install aluminum honduits4boRes4or Tittings in hontaht Pit: honhrete or eart: O

VO 7nstall surTahe rahePays only P: ere indihated on CraPingsO

cO2 7DSGALLAG7UD

AO womply Pit: D1wA E and D1wA E0E Tor installation reI uirements eRhept P: ere reI uirements on CraPings or in t: is artihle are strihterOwomply Pit: D1wA E02 Tor aluminum honduitsOwomply Pit: DV- A q0 limitations Tor types oTrahePays alloPed in spehiTh ohhupanhies and number oTTloorsO

BO Keep rahePays at least 3 inh: es ZE50 mm& aPay Trom parallel runs oTTlues and steam or : otN Pater pipesO7nstall : oriWontal rahePay runs above Pater and steam pipingO

wO womplete rahePay installation beTore starting honduhtor installationO

CO womply Pit: reI uirements in Sehtion 23052/ ,Fangers and Supports Tor 1lehtrihal Systems, Tor : angers and supportsO

1O Arrange stubNups so hurved portions oTbends are not visible above Tinis: ed slabO

VO 7nstall no more t: an t: e eI uivalent oTt: ree / 0Ndegree bends in any honduit run eRhept Tor hontrol Piring honduits4 Tor P: ih: TePer bends are alloPedOSupport Pit: in E2 inh: es Zc00 mm& oT h: anges in direhtionO

. O wonheal honduit and 1Y G Pit: in Tinis: ed Palls4 heilings4 and Tloors unless ot: erPise indihatedO 7nstall honduits parallel or perpendihular to building linesO

FO Support honduit Pit: in E2 inh: es Zc00 mm&oTenhlosures to P: ih: attah: edO

7O G: readed wonduit) oints41Rposed to ' et4Camp4worrosive4or Uutdoor wonditions8Apply listed hompound to t: reads oT rahePay and Tittings beTore maxing up zointsO VolloP hompound manuTahturerXs Pritten instruhtionsO

)O woat TieldNhut t: reads on - " wNhoated rahePay Pit: a horrosionNpreventing honduhtive hompound prior to assemblyO

KO MahePay Germinations at Lohations Subzeht to Yoisture or " ibration8f se insulating bus: ings to proteht honduhtors inhluding honduhtors smaller t: an DoC9 A' . O

LO Germinate t: readed honduits into t: readed : ubs or Pit: lohxnuts on inside and outside oTboRes or habinetsO7nstall bus: ings on honduits up to ENE.9Nnh: trade siWe and insulated t: roat metal bus: ings on ENE.2Nnh: trade siWe and larger honduits terminated Pit: lohxnutsO7nstall insulated t: roat metal grounding bus: ings on servihe honduitsO

YO 7nstall rahePays sI uare to t: e enhlosure and terminate at enhlosures Pit: lohxnutsO7nstall lohxnuts : and tig: t plus E.9 turn moreO

DO Co not rely on lohxnuts to penetrate nonhonduhtive hoatings on enhlosuresOMemove hoatings in t: e lohxnut area prior to assembling honduit to enhlosure to assure a hontinuous ground pat: O

UO wut honduit perpendihular to t: e lengt: OVor honduits 2Nnh: trade siWe and larger4use roll hutter or a guide to maxe hut straig: t and perpendihular to t: e lengt: O

-O 7nstall pull Pires in empty rahePaysOf se polypropylene or monoTilament plastih line Pit: not less t: an 200Nlo tensile strengt: OLeave at least E2 inh: es oT slahx at eah: end oT pull PireOwap underground rahePays designated as spare above grade alongside rahePays in useO

QO SurTahe MahePays8

EO 7nstall surTahe rahePay Pit: a minimum 2Nnh: radius hontrol at bend pointsO
2O Sehure surTahe rahePay Pit: shrePs or ot: er anh: orNype devihes at intervals not eRheeding 9j inh: es ZE200 mm& and Pit: no less t: an tPo supports per straig: t rahePay sehtionOSupport surTahe rahePay ahhording to manuTahturerXs Pritten instruhtionsOGape and glue are not ahheptable support met: odsO

MO 7nstall rahePay sealing Tittings at ahhessible lohations ahhording to DV- A q0 and Till t: em Pit: listed sealing hompoundOVor honhealed rahePays4install eah: Titting in a Tius: steel boR Pit: a blanx hover plate : aving a Tinis: similar to t: at oT adzahent plates or surTahesO7nstall rahePay sealing Tittings ahhording to DV- A q0O

SO 7nstall devihes to seal rahePay interiors at ahhessible lohationsOLohate seals so no Tittings or boRes are betPeen t: e seal and t: e TolloPing h: anges oTenvironmentsOSeal t: e interior oTall rahePays at t: e TolloPing points8

EO ' : ere honduits pass Trom Parm to hold lohations4 suh: as boundaries oT reTrigerated spahesO
2O ' : ere an underground servihe rahePay enters a building or struhtureO
cO ' : ere ot: erPise rel uired by DV- A q0O

GO womply Pit: manuTahturerXs Pritten instruhtions Tor solvent Pelding MDw and TittingsO

f O VleRible wonduit wonnehtions8womply Pit: D1Y A M" cOf se a maRimum oTq2 inh: es ZEj c0 mm& oTTeRible honduit Tor eI uipment subzeht to vibration4 noise transmission4 or movementk and Tor transTormers and motorsO

EO f se LVY w in damp or Pet lohations subzeht to severe p: ysihal damageO
2O f se LVY w in damp or Pet lohations not subzeht to severe p: ysihal damageO

" O Y ount boRes at : eig: ts indihated on CraPingsO7Tmounting : eig: ts oTboRes are not individually indihated4 give priority to ACA reI uirementsO7nstall boRes Pit: : eig: t measured to henter oTboR unless ot: erPise indihatedO

' O ForiWontally separate boRes mounted on opposite sides oTPalls so t: ey are not in t: e same vertihal h: annelO

(O Lohate boRes so t: at hover or plate Pill not span diTTerent building Tnis: esO

6O Support boRes oT t: ree gangs or more Trom more t: an one side by spanning tPo Traming members or mounting on brahxets speiTThally designed Tor t: e purposeO

HO Vasten zunhtion and pull boRes to or support Trom building struhtureOCo not support boRes by honduitsO

c0 SL11" 1 ADC SL11" 1NS1AL 7DSGALLAG7UD VUM1L1wGM7wAL - 1D1GMAG7UDS

AO 7nstall sleeves and sleeve seals at penetrations oTeRterior Toor and Pall assembliesOwomply Pit: reI uirements in Sehtion 230599 ,Sleeves and Sleeve Seals Tor 1lehtrihal MahePays and wablingO,

c09 V7M1SGU- - 7D.

AO 7nstall Trestopping at penetrations oT TreNated Toor and Pall assembliesO womply Pit: reI uirements in Sehtion 0qj 9Ec ,- enetration VirestoppingO,

c05 - MUG1wG7UD

AO - roteht hoatings4Tnis: es4and habinets Trom damage and deterioratiOn

EO Mepair damage to galvaniWed Tnis: es Pit: WhhNih: paint rehommended by manuTahturerO
2O Mepair damage to -" w hoatings or paint Tnis: es Pit: math: ing touh: up hoating rehommended by manuTahturerO

1DC UV S1wG7UD 2305cc

Section 260548.16
Seismic Controls For Electrical Systems

PAR1 - GECNCRAL

- .- RCLA1CD DOf UMCN1S

A. Drawings and general provisions oVthe f ontract, including Eeneral and Supplementary f onditions and Division 0- SpeciVcation Sections, apply to this Section.

- .2 SUMMARY

A. Section :ncludesI

- . Restraint channel bracings.
2. Restraint cables.
F. SeismicGestraint accessories.
H. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related RequirementsI

- . Section 230524 WGangers and Supports Vor Clectrical SystemsWVor commonly used electrical supports and installation requirements.

- .F Af 1:ON SUBM:11ALS

A. Product DataI kor each type oVproduct.

- . :llustrate and indicate style, material, strength, Vastening provision, and Vinish Vor each type and sij e oV seismicGestraint component used.
a. Annotate to indicate application oVeach product submitted and compliance with requirements.

B. DelegatedGDesign SubmittalI kor each seismicGestraint device.

- . :nclude design calculations and details where standard product is not used Vor selecting seismic restraints complying with perVormance requirements, design criteria, and analysis data signed and sealed by the qualiVed proVessional engineer responsible Vor their preparation.
2. Design f alculationsI f alculate static and dynamic loading caused by equipment weight, operation, and seismic Vorces required to select seismic restraints and Vor designing vibration isolation bases.

a. f oordinate design calculations with wind load calculations required Vor equipment mounted outdoors. f omply with requirements in other Sections Vor equipment mounted outdoors.

F. SeismicGRestraint DetailsI

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic restraint and vibration isolation details with wind restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic restraint ratings, by IAPMO ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic restraint designs must be signed and sealed by a qualified professional engineer.

C. Comply with NFPA 70.

PAR1 2 GPRODUf 1S

2.- PCRkORMANf C RC) U:RCMCN1S

A. SeismicGRestraint LoadingI

- . Site f lass as DeVined in the :Bf I f .
2. Assigned Seismic Use Eroup or Building f ategory as DeVined in the :Bf I :::.

a. f omponent :mportance kactorI - .5
b. f omponent Response ModiVication kactorI 2.5
c. f omponent AmpliVication kactorI 2.5

F. Design Spectral Response Acceleration at Short Periods J0.2 Second(.
H. Design Spectral Response Acceleration at - .0GSecond Period.

2.2 RCS1RA:N1 f 6ANNCL BRAf :NES

A. ManuVacturersI Sub;ect to compliance with requirements, provide products by one oVthe Vollowing, or approved equalI

- . BGline, an Caton business.
2. 6ilti, :nc.

B. DescriptionI MkMAGH, shopGor VeldGabricated bracing assembly made oVslotted steel channels with accessories Vor attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosionGesistant coating/ rated in tension, compression, and torsion Vorces.

2.F RCS1RA:N1 f ABLCS

A. ManuVacturersI Sub;ect to compliance with requirements, provide products by the Vollowing, or approved equalI

- . Kinetics Noise f ontrol, :nc.

B. Restraint f ablesI AS1M A H-42 stainlessGsteel cables. Cnd connections made oVsteel assemblies with thimbles, bracXets, swivel, and bolts designed Vor restraining cable service/ with a minimum oVtwo clamping bolts Vor cable engagement.

2.H SC:SM:f GRCS1RA:N1 Af f CSSOR:CS

A. ManuVacturersI Sub;ect to compliance with requirements, provide products by one oVthe Vollowing, or approved equalI

- . BGline, an Caton business.
2. Kinetics Noise f ontrol, :nc.

B. 6angerGRod StiVenerI Steel tube or steel slottedGsupportGsystem sleeve with internally bolted connections to hanger rod.

f . 6inged and Swivel Brace AttachmentsI MultiVunctional steel connectors Vor attaching hangers to rigid channel bracings

D. Bushings Vor kloorGMounted Cquipment Anchor BoltsI Neoprene bushings designed Vor rigid equipment mountings and matched to type and sij e oVanchor bolts and studs.

C. Bushing Assemblies Vor 8 allGMounted Cquipment AnchorageI Assemblies oVneoprene elements and steel sleeves designed Vor rigid equipment mountings and matched to type and sij e oVattachment devices used.

k. Resilient :solation 8 ashers and BushingsI OneGpiece, molded, oilGand waterGresistant neoprene, with a Vlat washer Vace.

2.5 MCf 6AN:f AL ANf 6OR BOL1S

A. ManuVacturersI Sub;ect to compliance with requirements, provide products by one oVthe Vollowing, or approved equalI

- . BGline, an Caton business.
2. 6ilti, :nc.

B. Mechanical Anchor BoltsI DrilledGin and studGwedge or VemaleGwedge type in j incGcoated steel Vor interior applications and stainless steel Vor exterior applications. Select anchor bolts with strength required Vor anchor and as tested according to AS1M C HTT.

2.3 AD6CS:' C ANf 6OR BOL1S

A. ManuVacturersI Sub;ect to compliance with requirements, provide products by the Vollowing, or approved equalI

- . 6ilti, :nc.

B. Adhesive Anchor BoltsI DrilledGin and capsule anchor system containing P' f or urethane methacrylateGbased resin and accelerator, or in;ected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with j incGcoated steel Vor interior applications and stainless steel Vor exterior applications. Select anchor bolts with strength required Vor anchor and as tested according to AS1M C HTT.

PAR1 F GC9Cf U1:ON

F.- C9AM:NA1:ON

A. Cxamine areas and equipment to receive seismicGcontrol devices Vor compliance with requirements Vor installation tolerances and other conditions aVVecting perVormance oVthe 8 orX.

B. CxamineroughinGin Vor reinVorcement and castGinGplace anchors to veriVy actual locations beVore installation.

f . Proceed with installation only aVter unsatisVactory conditions have been corrected.

F.2 APPL:f A1:ONS

A. Multiple Raceways or f ablesI Secure raceways and cables to trapej e member with clamps approved Vor application by an evaluation service member oVan agency acceptable to authorities having ;urisdiction.

B. 6angerGRod StiWeneersI :nstall hangerGrod stiWeners where indicated or scheduled on Drawings to receive them and where required to prevent bucXling oVhanger rods caused by seismic Vorces.

f . Strength oVSupport and SeismicGRestraint AssembliesI 8 here not indicated, select sij es oVcomponents so strength will be adequate to carry present and Vuture static and seismic loads within speciVied loading limits.

F.F SC:SM:f GRCS1RA:N1 DC' :f C :NS1ALLA1:ON

A. Cquipment and 6anger RestraintsI

- . :nstall resilient, boltGisolation washers on equipment anchor bolts where clearance between anchor and ad;acent surVace exceeds 0.-25 inch JF.2 mm(.
2. :nstall seismicGrestraint devices using methods approved by an agency acceptable to authorities having ;urisdiction providing required submittals Vor component.

B. :nstall cables so they do not bend across edges oVad;acent equipment or building structure.

f . :nstall bushing assemblies Vor mounting bolts Vor wallGmounted equipment, arranged to provide resilient media where equipment or equipmentGmounting channels are attached to wall.

D. Attachment to StructureI :VspeciVic attachment is not indicated, anchor bracing to structure at Vanges oVbeams, at upper truss chords oVbar ;oists, or at concrete members.

C. DrilledGin AnchorsI

- . :dentiVy position oVreinVorcing steel and other embedded items prior to drilling holes Vor anchors. Do not damage existing reinVorcing or embedded items during coring or drilling. NotiVy the structural engineer iV reinVorcing steel or other embedded items are encountered during drilling. Locate and avoid preGstressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved Vull design strength.
F. 8edge AnchorsI Protect threads Vrom damage during anchor installation. 6eavyGduty sleeve anchors shall be installed with sleeve Vully engaged in the structural element to which anchor is to be Vastened.
H. Adhesive AnchorsI f lean holes to remove loose material and drilling dust prior to installation oVadhesive. Place adhesive in holes proceeding Vrom the bottom oVthe hole and progressing toward the surVace in such a manner as to avoid introduction oVair pocXets in the adhesive.
5. Set anchors to manuVacturerGs recommended torque using a torque wrench.
3. :nstall j incGcoated steel anchors Vor interior and stainlessGsteel anchors Vor exterior applications.

F.H Af f OMMODA1:ON Ok D:kk CRCN1:AL SC:SM:f MO1:ON

A. :nstall Vexible connections in runs oVraceways, cables, wireways, cable trays, and busways where they cross seismic ;oints, where ad;acent sections or branches are supported by diWerent structural elements, and where connection is terminated to equipment that is anchored to a diWerent structural element Vrom the one supporting them as they approach equipment.

F.5 k:CLD) UAL:1Y f ON1ROL

A. Per\orm the \ollowing tests and inspections

- . Provide evidence oVrecent calibration oVtest equipment by a testing agency acceptable to authorities having ;urisdiction.
2. Schedule test with Owner, through Architect, be\ore connecting anchorage device to restrained component Junless post-connection testing has been approved(, and with at least seven days' advance notice.
F. Obtain Architect's approval be\ore transmitting test loads to structure. Provide temporary load-spreading members.
H. 1est at least 2 oVeach type and sij e oVinstalled anchors and \asteners selected by Architect.
5. 1est to 40 percent oVrated proo\load oVdevice.

B. Seismic controls will be considered de\ective iV they do not pass tests and inspections.

f . Prepare test and inspection reports.

F.3 ADzUS1:NE

A. Ad;ust restraints to permit \ree movement oVequipment within normal mode oVoperation.

CND Ok SCf 1:ON 2305HT.- 3

Section 260553
Identification For Electrical Systems

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 90 deg F (32 deg C), ambient; 176 deg F (80 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Warning labels and signs shall include, but are not limited to, the following legends:

1. Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES. " (for 120/208 equipment and) 42 INCHES (for 277/480V equipment).
3. Ark Flash Hazard label per NFPA 70E.

2.3 LABELS

A. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

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

a. Brady Corporation.
b. Marking Services, Inc.

B. Self-Adhesive Labels:

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

a. A'n D Cable Products.
b. Brady Corporation.
c. Brother International Corporation.
d. Emedco.
e. Grafoplast Wire Markers.
f. Ideal Industries, Inc.
g. LEM Products Inc.
h. Marking Services, Inc.

2. Preprinted 3-mil- (0.08-mm-) thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

    a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable or raceway diameter, such that the clear shield overlaps the entire printed legend.

3. Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

    a. Nominal Size: 3.5-by-5-inch (76-by-127-mm).

4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

A. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

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

    a. The contractor to select the manufacturer.

2.5 TAPES AND STENCILS:

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

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

    a. Carlton Industries, LP.
    b. Champion America.
    c. Ideal Industries, Inc.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) thick; compounded for outdoor use.

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

    a. Brady Corporation.
    b. Carlton Industries, LP.

C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. Emedco.
d. Grafoplast Wire Markers.
e. LEM Products Inc.
f. Marking Services, Inc.

B. Write-On Tags:

1. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:

a. Carlton Industries, LP.

2. Polyester Tags: 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. inches (129 sq. cm), minimum 1/16-inch.
b. For signs larger than 20 sq. inches (129 sq. cm), 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

3. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:

a. Brady Corporation.
b. Carlton Industries, LP.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by the following, or approved equal:

1. Ideal Industries, Inc.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   1. In Spaces Handling Environmental Air: Plenum rated.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

J. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 25-foot (15-m) maximum intervals.

3.3 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 20 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at [10-foot (3-m)] [30-foot (10-m)] maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

   1. Indicate a power source and load
   2. Circuit number

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in pull and junction boxes, use color-coding conductor tape to identify the phase.

   1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

      a. Color shall be factory applied for wire size #10 and smaller, field applied for sizes No. 8 AWG and larger if authorities having jurisdiction permit.
      b. Colors for 208/120-V Circuits:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.

      c. Colors for 480/277-V Circuits:
         1) Phase A: Brown.
         2) Phase B: Orange.
         3) Phase C: Yellow.

      d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels. Coordinate with building existing standards.

E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, use write-on tags and self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

F. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power transformers.
    b. Controls with external control power connections.
    c. Panels.
    d. Enclosed switches and circuit breakers
    e. VFD

J. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label] Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-

mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

c. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved laminated acrylic or melamine label.

b. Enclosures and electrical cabinets.

c. Access doors and panels for concealed electrical items.

d. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.

e. Motor-control centers.

f. Enclosed switches.

g. Enclosed circuit breakers.

h. Enclosed controllers.

i. Variable-speed controllers.

j. Push-button stations.

k. Remote-controlled switches, dimmer modules, and control devices.

l. Monitoring and control equipment.

END OF SECTION 260553

Section 260923
Lighting Control Devices

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electronic time switches.
2. Indoor occupancy and vacancy sensors.
3. Switchbox-mounted occupancy sensors.
4. Digital timer light switch.
5. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's warranties.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. HUBBELL NX

B. Acuity NDTC

C. Approved Equal

2.2 ELECTRONIC TIME SWITCHES

A. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. 120V AC.
3. Programs:
    a. Eight channels; each channel is individually programmable with two on-off set points on a 24-hour schedule, allowing different set points for each day of the week, and an annual holiday schedule that overrides the weekly operation on holidays.

4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
5. Astronomic Time: All channels.
6. Automatic daylight savings time changeover.
7. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Requirements for Sensors:

1. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

4. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.

5. Bypass Switch: Override the "on" function in case of sensor failure.
6. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); turn lights off when selected lighting level is present.

B. Dual-Technology Type: Wall and Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6 inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch (23 200 sq. mm), and detect a person of average size and weight moving not less than 12 inch (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inch/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of [1000 sq. ft. (110 sq. m)] [2000 sq. ft. (220 sq. m)] [3000 sq. ft. (330 sq. m)] when mounted 48 inch (1200 mm) above finished floor.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
4. Switch Rating: Not less than 800 VA LED load at 120 V, 1200 VA or LED load at 277 V, and 800 W incandescent.

2.5 DIGITAL TIMER LIGHT SWITCH

A. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in [**10**] [**20**] minute increments.

1. Rated 960 W at 120 V(ac) for tungsten lighting, 10 A at 120 V(ac) or 10 A at 277 V(ac) for fluorescent or LED lighting, and 1/4 hp at 120 V(ac).
2. Standards: Comply with UL 20.
3. Integral relay for connection to BAS.
4. Voltage: Match the circuit voltage.

2.6 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

3.2 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.

B. Label time switches and contactors with a unique designation.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

END OF SECTION 260923

Section 262200
Low-Voltage Transformers

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Distribution dry-type transformers rated 600 V and less, with capacities up to 500 kVA. Refer to drawings for transformer rating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Acme Electric Corporation.
2. Controlled Power Company; an Emerson company.
3. Dongan Electric Manufacturing Company.
4. Eaton.
5. Federal Pacific.
6. General Electric Company.
7. Hammond Power Solutions Inc.
8. Jefferson Electric, Inc.
9. Lincoln Electric Products Co., Inc.
10. MGM Transformer Company.
11. Powersmiths International Corp.
12. Siemens Power Transmission & Distribution, Inc.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 61 gray.

F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity

G. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

H. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40-deg C ambient temperature.

I. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

J. Neutral: Rated 100% of phase conductors.

K. Fungus Proofing: Permanent fungicidal treatment for coil and core.

L. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 INSTALLATION

A. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

B. Secure transformer to concrete base according to manufacturer's written instructions.

C. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

D. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections. Perform scan in coordination with scan under section 260519 “Low Voltage Electrical Power Conductors”

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltage and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

Section 262416
Panelboards

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. MCCB: Molded-case circuit breaker.

D. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

   1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
   2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

   1. Include dimensioned plans, elevations, sections, and details.
   2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
   3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   4. Detail bus configuration, current, and voltage ratings.
   5. Short-circuit current rating of panelboards and overcurrent protective devices.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include wiring diagrams for power, signal, and control wiring.
   8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI Type: (1) spares for each type.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation when stored in unconditioned space.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 50 deg F (minus 10 deg C) to plus 90 deg F (plus 32 deg C).

b. Altitude: Not exceeding 3300 feet (1000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 3300 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager/ Owner no fewer than 5 days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Construction Manager's/Owner's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

2. Height: 84 inches maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.

4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Finishes:

    a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Galvanized steel.
    c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: Top or Bottom, contractor to coordinate.
2. Main Breaker: As specified on drawing and/or panel schedule.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity. Bus shall be fully rated the entire length

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
4. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.

J. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices.

K. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Blank covers for future devices. Total panel capacity 42 circuits, unless otherwise indicated on drawings.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens.
4. Cutler Hummer.
5. Square-D/Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or Main Lug as indicated on drawings and/or panel schedule.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens.
4. Cutler Hummer.
5. Square-D/ Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. GFCI Circuit Breakers: Single-pole configurations with Class A ground-fault protection (6-mA trip).
3. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Breaker handle indicates tripped status.
    c. UL listed for reverse connection without restrictive line or load ratings.
    d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    e. Provide handle ties for all single phase circuits sharing a neutral

2.5 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Typed circuit directory mounted inside panelboard door with transparent plastic protective cover. Provide revised directly if circuits change

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
   2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Mount top of trim 72 inches (1829 mm) above finished floor unless otherwise indicated.

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

I. Mount surface-mounted panelboards to steel slotted supports 1 1/4 inch (32 mm) in depth. Orient steel slotted supports vertically.

J. Install overcurrent protective devices and controllers not already factory installed.

   1. Set field-adjustable, circuit-breaker trip ranges to lowest allowable setting given load characteristics.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

L. Install filler plates in unused spaces.

M. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the infrared scan tests and inspections as required in Section 260519 “Low Voltage Electrical Power Conductors and Cables.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 10 percent.
5. Revise panel schedule and As-Built drawings to reflect changes made.

END OF SECTION 262416

Section 262816
Enclosed Switches And Circuit Breakers

PAR1 5 - GHEHRAL

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Section 265119
Led Interior Lighting

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests IES LM-79 and IES LM-80.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

D. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Ceiling-mounted projectors.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

D. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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

B. CRI of minimum 80. CCT of 3500 K.

C. Rated lamp life of 50,000 hours.

D. Lamps dimmable from 100 percent to 0 percent of maximum light output.

E. Internal driver.

F. Nominal Operating Voltage: 120 V ac or 277 V ac via multi voltage supply.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

G. Housings:

1. Extruded-aluminum housing and heat sink.

2.3 LINEAR INDUSTRIAL

A. Minimum 5,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

B. Housing and heat sink rated to the following:
1. NEMA 1X.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers:
1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Powder-coat finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following LED engine characteristics:

a. "USE ONLY" and include specific LED engine.
b. LED engine, shape, size, wattage, and luner output.
c. CCT and CRI for all luminaires.

2.5 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.6 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.

F. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

Section 31 0000
EARTHWORK

1.1 General earthwork requirements shall conform to the following minimum standards:

A. Provide positive drainage away from all structures.

B. Unless otherwise noted, minimum slope shall be ¼ inch per foot or 2% and a maximum slope shall not exceed 3:1 (h:v) or 33% for non-paved surfaces. Paved surfaces shall have a minimum grade or 1% and have positive drainage off of the pavement.

C. Grades on designated handicapped accessible areas/routes shall comply with the provisions of the Americans with Disabilities Act.

D. Notify the PPR immediately if slope requirements cannot be met. At no time will slopes in excess of those above the maximum allowed, be accepted, unless prior approval is received in writing by PPR.

E. Grade earthen, non-paved, surfaces to a smooth finish. Slope lawn areas in swales to a gentle crown along the centerline.

F. Grade all seeded fine lawn areas flush with finish grade. Adjust finished grade to the proper depth where sod abuts paved areas.

G. Grade all tree/shrub/groundcover planting beds to 3 inches below top of abutting curbs, paving, or lawn areas to allow for mulching.

H. Adjust existing and new manhole, catch basins, and drains rim/grate elevations to new grade elevations (pavement or soil).

I. Finished surfaces shall be graded smooth and even with no abrupt or awkward changes in grade.

J. Provide properly compacted subgrades of native soil or approved fill. Native soils, fill, or subgrades deemed insufficient shall be removed and replaced with appropriate material. Subgrades shall be inspected by a qualified inspector to ensure compaction requirements are met. Submit test reports and field logs to PPR for review and for record.

K. Existing on-site soils should be evaluated for both suitability for use in construction as well as environmentally for contaminants by licensed and qualified professionals such geotechnical engineers and environmental scientists. Many sites throughout the City include various types of urban fill. In some cases there may be abandoned structures below grade. These soils and features should be evaluated before design and engineering newly planned features. Also, environmental due diligence and/or testing should be completed near the beginning of design and engineering to ascertain if on-site materials are clean or regulated. Testing of existing on-site soils and materials shall comply with the requirements of Pennsylvania Department of Environmental Protection requirements for fill management whether it is determined to be clean or regulated. Submit geotechnical testing and environmental due diligence reports to PPR for review and for record.

L. Any soil materials leaving the site or being brought to the site shall comply with the Pennsylvania Department of Environmental Protection requirements for fill management.

M. Environmental due diligence: investigative techniques, including, but not limited to, visual property inspections, electronic data base searches, review of property ownership, review of property use history, sanborn maps, environmental questionnaires, transaction screen, analytical testing,

environmental assessments or audits. Submit all environmental due diligence reports to PPR for review and for record.

N. Analytical testing is not a required part of due diligence unless visual inspection and/or review of the past land use of the property indicates that the fill may have been subjected to a spill or release of a regulated substance. If the fill may have been affected by a spill or release of a regulated substance, it must be tested to determine if it qualifies as clean fill. Testing should be performed in accordance with appendix a of PADEP's policy "management of fill".

O. Fill material that does not qualify as clean fill is regulated fill. Regulated fill is waste and must be managed in accordance with the municipal or residual waste regulations in 25 pa code chapters 287 residual waste management or 271 municipal waste management, whichever is applicable.

P. Designers and contractors shall comply with the Pennsylvania Underground Utility Line Protection Law, Act 287 of 1974, as amended by Act 50 of 2017. This includes contacting the Pennsylvania One Call System or 811 as required by law.

Q. Designers and contractors, in additional to complying with the Pennsylvania Underground Utility Line Protection Law requirements shall research available utility records from the project owner for the site or facility. Upon evaluation of these records the designer or contractor can evaluate the need for extensive underground utility locating depending the project. The designer or contractor shall determine the need and level of underground utility located needed for the project in conformance with the American Society of Civil Engineers (ASCE) National Consensus Standard – ASCE C-I 38-02, Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data. The designer or contractor shall determine the Quality Level of utility located required by the project, Levels D, C, B, or A. The costs associated with underground utility locating services shall be evaluated and balanced with the available utility information, conditions in the field, the type of project being proposed, the risks associated with utility conflict and/or damage, and the ability of a utility locator to obtain information. These evaluations shall be done in consultation with Philadelphia Parks and Recreation.

END OF SECTION

Section 31 1000
SITE CLEARING

1.1 Site Clearing shall confirm to the following minimum standards:

A. Preparation:

1. Protect and maintain benchmarks and survey control points from disturbance during construction.

2. Protect existing site improvements to remain from damage during construction.

    a. Restore damaged improvements to their original condition, as acceptable to Owner.

B. Temporary Erosion and Sedimentation Control

1. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction.

2. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established

3. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

C. Utilities

1. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.

    a. Verify that utilities have been disconnected and capped before proceeding with site clearing.

2. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

    a. Arrange with utility companies to shut off indicated utilities.

    b. Owner will arrange to shut off indicated utilities when requested by Contractor.

3. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated

    a. Notify Architect not less than two days in advance of proposed utility interruptions.

    b. Do not proceed with utility interruptions without Architect's written permission.

D. Clearing and Grubbing

1. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

2. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

    a. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground

E. SITE IMPROVEMENTS

1. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction

2. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

    a. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically

    b. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

F. DISPOSAL

1. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property

END OF SECTION

Section 32 1313
CONCRETE PAVING

1.1 Concrete paving shall conform to the following minimum standards:

A. Minimum Strength: 4,000 psi at 28 days.

B. Provide sealed/caulked expansion joints.

C. Provide control joints at a spacing as required to prevent cracking within panels.

D. Finish shall be non-slip broom type finish.

E. Joints shall be tooled prior to broom finishing to eliminate “window pane” appearance. Sawcut joints are not preferred. If designer/contractor wishes to utilize sawcut joints prior approval shall be obtained from Philadelphia Parks and Recreation.

F. Concrete paving shall conform to the flowing standards:

1. ACI 117 – Specification for Tolerance for Concrete Construction and Materials

2. ACI 318 – Building Code Requirements for Reinforced Concrete

3. PennDOT 408 – Construction Specifications

4. PennDOT RC-67M – Curb Ramp and Sidewalk Construction Details

G. Concrete shall contain either a water-reducing, plasticizing admixture or a high-range water-reducing admixture. All concrete shall contain an air-entraining admixture to provide 5%-7% air entrainment. Maximum chloride content shall be 0.15%. Maximum water/cement ratio shall be 0.45. Maximum design slump of 3 inches without super plasticizers. Aggregate size shall be 3/4 of an inch with a designation of 4S per ASTM C33.

H. Reinforcing: PPR prefers most pavements be unreinforced to facilitate future repairs and/or replacements. In some cases, reinforcing is required either by site conditions or by design requirements such as some sprayground elements require reinforcing. If reinforcing is provided if shall meet the following:

1. Welded wire fabric shall be galvanized and comply with ASTM A185.

2. Reinforcing steel bars shall be grade 60 per ASTM A615.

I. Submit mix design to the owner's representative for approval. The owner's representative may reject design mix for non-compliance.

J. Moist cure all concrete work and commence moist curing as soon as finishes will not be marred. Insulating blankets waterproofed kraft paper, or polyethylene film as per ASTM C171 shall be used to keep the concrete continuously moist during the curing process.

K. Minimum Paving Thickness:

1. Pedestrian Walkways: Minimum 4 inches thick, no reinforcement, on 4 inches compacted crushed aggregate (PennDOT 2A Modified or 2B Clean Aggregate or AASHTO No. 57 Stone or equivalent).

2. Vehicular and Access Drives: Minimum 6 inches thick on 6 inches compacted crushed aggregate (PennDOT 2A Modified or 2B Clean Aggregate or AASHTO No. 57 Stone or equivalent). Specification of reinforcement shall be evaluated based upon vehicular use. Thickness should be evaluated based on vehicle weights, axil loading, amount of usage, and local soil conditions and increased above the minimum if conditions warrant. Designer shall provide thickness.

3. Driveway Aprons and Sidewalks within Rights of Way: Follow Department of Streets standards of construction.

4. Spraygrounds: 6 inches thick on 6 inches of compacted crushed aggregate (PennDOT 2A Modified or 2B Clean Aggregate or equivalent). Reinforcement shall be per sprayground equipment manufacturer's recommendations/specifications. Thickening of slabs and or foundations for sprayground features shall be per sprayground equipment manufacturer's recommendations/specifications.

L. Drainage: Pavements shall have positive drainage off of the surface. Provide a minimum cross pitch of 1.0% and a maximum cross pitch of 2.0%. Plaza and sprayground areas shall have maximum grades of 2.0% in any direction.

M. Tolerances for Paving:

1. Pavements in longitudinal direction, the gap below a 10 ft unleveled straightedge resting on high spots shall not exceed 1/8 inch.

2. Pavements in transverse direction, the gap below a 10 ft unleveled straightedge resting on high spots shall not exceed 1/4 inch.

3. Ramps, sidewalks, and intersections, in any direction, the gap below a 10 ft unleveled straightedge resting on high spots shall not exceed 1/4 inch.

4. In no case shall grades on any pavements either designated or intended to be accessible per the Americans with Disabilities Act (ADA) exceed the grade maximums noted in the ADA or ADA Accessibility Guidelines (ADAAG).

END OF SECTION

Section 32 3113
CHAIN-LINK FENCING AND GATES

1.1 Chain-Link Fencing shall conform to the following minimum standards:

A. General Site Fencing Standards (Chain-link):

1. Height: All chain-link fencing will either measure 6’ tall (72”) or 8’ tall (96”) in height from the finished grade, unless otherwise requested or approved by Philadelphia Parks and Recreation.

2. Gates: All gates are to match the height of the new fencing that they are linked to. Gate widths will either be 4’ (48”) for single man gates or 8’ (96”) for double man gates. Fabric will match the specifications of the new fence that it is linked to.

3. Fabric: All chain-link fabric will be vinyl coated and have a minimum weave of 2”x2” with 9GA tie wire, knuckled on both top and bottom. Cut ends of fence fabric shall be turned or knuckled over in the field to sharp wire ends are not exposed. Tie wires will be 24” on center, unless otherwise approved by Philadelphia Parks and Recreation. The color will be black, unless otherwise stated/approved by Philadelphia Parks and Recreation.

a. For fencing along the perimeter of athletic fields, baseball/softball fields, and sport courts that fabric shall be installed on the field or court side facing the field or court.

4. Posts: Minimum 2” (outside diameter) galvanized steel, painted black. Posts should have a maximum spacing of 8’(96”) on center per section of chain-link fencing. All Terminal posts will have caps and tension bar. All line posts will have top and bottom connectors.

5. Rails: Minimum 1-5/8” (outside diameter) galvanized steel, painted black. The bottom rail will be a 2” from finished grade.

6. Footings: Footings will be minimum 3500 PSI concrete at 36” depth below finished grade and have a 12” diameter, unless otherwise required. The new post will be set at a depth of 30” from finished grade within the new footing.

7. Approved Manufacturers:

a. Northeast Fence and Iron Works – 8451 Hegerman Street, Philadelphia, Pennsylvania 19136, Phone: (215) 335-1681, Web: http://www.northeastfence.net/
b. Stephens Pipe and Steel, LLC – 300 Streibeigh Lane, Montoursville, Pennsylvania 17754, Phone: (888) 275-1638, Web: http://www.spsfence.com

c. Master Halco – 3010 Lyndon B Johnson Freeway, Suite 800, Dallas, Texas 75234, Phone: (800) 883-8384, Web: www.masterhalco.com

d. Equal approved Philadelphia Parks and Recreation

B. Dog Park Fencing Standards (Chain-link):

1. Height: The minimum height for all dog park enclosures is 72 inches (6 feet).

2. Gates: All gates are to match the height of the fence they are abutting. Gate widths will either be 4 feet (48 inches) wide for single man gates or 8 feet (96 inches) for double wide man gates. The fabric on the gate will match the specifications of the new fence they are linked to.

3. Fabric: All chain-link fabric will be coated vinyl with a maximum weave of 1”x1” for the safety of both dogs and pedestrians outside of the fenced in area. The color will be black, unless otherwise stated/approved by Philadelphia Parks and Recreation.

4. Posts: Minimum 2” (outside diameter) galvanized steel, painted black. Posts should have a maximum spacing of 8’ (96”) on center per section of chain-link fencing. All Terminal posts will have caps and tension bar. All line posts will have top and bottom connectors.

5. Rails: Minimum 1-5/8” (outside diameter) galvanized steel, painted black. The bottom rail will be a 2” from finished grade.

6. Footings: Footings will be minimum 3500 PSI concrete at 36” depth below finished grade and have a 12” diameter, unless otherwise required. The new post will be set at a depth of 30” from finished grade within the new footing.

7. Approved Manufacturers:

   a. Northeast Fence and Iron Works – 8451 Hegerman Street, Philadelphia, Pennsylvania 19136, Phone: (215) 335-1681, Web: http://www.northeastfence.net/
   b. Stephens Pipe and Steel, LLC – 300 Streibeigh Lane, Montoursville, Pennsylvania 17754, Phone: (888) 275-1638, Web: http://www.spsfence.com
   c. Master Halco – 3010 Lyndon B Johnson Freeway, Suite 800, Dallas, Texas 75234, Phone: (800) 883-8384, Web: www.masterhalco.com
   d. Equal approved Philadelphia Parks and Recreation.

END OF SECTION

SECTION 323300
SITE FURNISHINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Benches
   2. Trash and Recycling Receptacles
   3. Storage Shed

B. Related Requirements:
   1. Section 312000 "Earth Moving" for excavation for installing concrete footings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

C. Samples for Initial Selection: For units with factory-applied finishes.

D. Samples for Verification: For each type of exposed finish, not less than 6-inch- long linear components and 4-inch- square sheet components.

E. Product Schedule: For site furnishings, use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Site furnishings manufacturer must be approved by Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain site furnishings from the following approved manufacturers:

1. Amish Backyard Structures
   193 Limestone Road, Oxford, PA 19363
   Phone: 717-875-4412
   www.amishbackyardstructures.com

2. Landscape Forms
   7800 East Michigan Ave, Kalamazoo, MI 49048
   Phone: 800-430-6209
   www.landscapeforms.com

3. Forms+Surfaces
   30 Pine Street, Pittsburgh, PA 15223
   Phone: 800-451-0410
   www.forms-surfaces.com

2.2 BENCHES

A. Alternate Backed Bench: Trio, Model No. SBTRO-72BW, manufactured by Forms+Surfaces.
   1. Frame: Cast Aluminum
      a. Frame Color: Deep Ocean Texture
   2. Slats: FSC 100% Cumaru
   3. Length: 6’
   4. Quantity: See Site Furnishings Schedule
   5. Installation: Surface mount with stainless steel hardware per manufacturer’s recommendations and specifications.

2.3 LITTER RECEPTACLES

A. Trash Receptacle: Grass Side Opening, manufactured by Landscape Forms.
   1. Frame: Steel
      a. Frame Color: Grass
   2. Size: 32-Gallon
   3. Lids and Tops: Side Deposit
   4. Internal Plastic Liner
   5. Quantity: See Site Furnishings Schedule
   6. Installation: Surface mount with non-corrosive hardware per manufacturer’s recommendations and instructions.

B. Recycling Receptacle: Grass Side Opening, manufactured by Landscape Forms.
   1. Frame: Steel
      a. Frame Color: Grass
   2. Size: 32-Gallon
   3. Lids and Tops: Side Deposit
   4. Internal Plastic Liner
   5. Quantity: See Site Furnishings Schedule
   6. Installation: Surface mount with non-corrosive hardware per manufacturer's recommendations and instructions.

2.4 STORAGE SHED

A. See Site Furnishings Schedule on Drawings for product information.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.

B. Verify that substrates are stable and capable of supporting the weight of items covered under this section.

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

3.2 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored positioned at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Install in conformance to applicable ADA guidelines and Owner's established accessibility policies.

END OF SECTION 323300

SECTION 329113
SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes planting soils for planting areas only, specified according to performance requirements of the mixes.

B. Related Requirements:

1. Section 329300 "Plants" for placing planting soil for plantings.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM) Standards as listed in Specification.

1.4 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

H. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

I. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

J. Planting Soil: Imported soil or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

K. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

L. SSSA: Soil Science Society of America.

M. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

N. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

O. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

P. USCC: U.S. Composting Council.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include recommendations for application and use.
   2. Include test data substantiating that products comply with requirements.
   3. Include sieve analyses for aggregate materials.
   4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:
      a. Manufacturer's qualified testing agency's certified analysis of standard products.
      b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
      c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Samples: For each bulk-supplied material, 1-quart (1-L) volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical

of the lot of material to be furnished and provide an accurate representation of composition, color, and texture.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1. Laboratories: Subject to compliance with requirements, qualified independent soil testing services include, but are not limited to:

a. Penn State College of Agricultural Sciences, Agricultural Analytical Services Lab
111 Ag Analytical Services Lab, University Park, PA 16802
Phone: 814-863-0841
Email: aaslab@psu.edu
www.agsci.psu.edu

b. Rutgers Soil Testing Laboratory
Rutgers, The State University of New Jersey
57 US Highway 1, New Brunswick, NJ 08901-8554
Phone: 848-932-9295
Email: soiltest@njaes.rutgers.edu
https://njaes.rutgers.edu/soil-testing-lab/

2. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.8 PRE-CONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing on-site soil and imported soil.

1. Notify Landscape Architect at least seven (7) days in advance of the dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.9 PRE-CONSTRUCTION SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by Contractor in presence of Landscape Architect under the direction of the testing agency.
1. Number and Location of Samples: Minimum number of representative soil samples to be determined by testing agency for each soil to be used or amended for landscaping purposes.
2. Procedures and Depth of Samples: To be determined by testing agency.
3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.10 PRE-CONSTRUCTION TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:
1. Soil Texture: Soil-particle, size-distribution analysis by the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
b. Hydrometer Method: Report percentages of sand, silt, and clay.
2. Bulk Density: Analysis according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
3. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
4. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
5. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85 percent compaction according to ASTM D698 (Standard Proctor).

C. Chemical Testing:
   1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
   2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
   4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil fertility analysis according to standard laboratory protocol of SSSA NAPT NEC-67, including the following:
   1. Percentage of organic matter.
   2. CEC, calcium percent of CEC, and magnesium percent of CEC.
   3. Soil reaction (acidity/alkalinity pH value).
   4. Buffered acidity or alkalinity.
   5. Nitrogen ppm.
   6. Phosphorous ppm.
   7. Potassium ppm.
   8. Manganese ppm.
   9. Manganese-availability ppm.
   10. Zinc ppm.
   11. Zinc availability ppm.
   12. Copper ppm.
   13. Sodium ppm.
   14. Soluble-salts ppm.
   15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
   16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3-Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
   1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1,000 sq. ft. for 6-inch depth of soil.
   2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inch depth of soil.

1.11 POST-CONSTRUCTION TESTING

A. Post-Construction Testing Service: Engage a qualified testing agency to perform post-construction analyses on amended planting soil with compost incorporated.
   1. Notify Landscape Architect seven (7) days in advance of the dates and times when laboratory samples will be taken.

B. Post-Construction Soil Analyses: For each amended soil, perform testing on soil samples and furnish soil analysis and a written report by a qualified testing agency performing the testing according to “Soil-Sampling Requirements” and “Testing Requirements” articles.
   1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.12 POST-CONSTRUCTION SOIL-SAMPLING REQUIREMENTS

A. General: Perform tests on soil samples according to the requirements in this article.

B. Fertility Testing:
   1. Percentage of organic matter.
      a. Organic matter content must be 4% minimum.
   2. CEC, calcium percent of CEC, and magnesium percent of CEC
   3. Soil reaction (acidity / alkalinity pH value).
      a. pH levels must be between 5.5 and 6.0. Lower pH by using elemental sulfur product. Peat moss or copper sulfate may not be used to lower pH.
   4. Buffered acidity or alkalinity.
   5. Nitrogen ppm.
   6. Phosphorus ppm.
   7. Potassium ppm.
   8. Manganese ppm.
   9. Manganese-availability ppm.
   10. Zinc ppm.
   11. Zinc-availability ppm.
   12. Copper ppm.
   13. Sodium ppm.
   14. Soluble-salts ppm.
      a. Soluble-salts measurement must be less or equal to 2 mmho/cm.
   15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
   16. Other deleterious materials, including their characteristics and content of each.
   17. Percolation test to ensure adequate drainage and proper mixing of compost.

C. Recommendations: The analysis tests shall show recommendations for soil additives or fertilizers to correct soil mixes’ deficiencies as necessary.

D. Deficiencies: Nutrient deficiencies shall be corrected at time of installation.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Do not move or handle materials when they are wet or frozen.
   4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 PLANTING SOIL

A. Planting Soil: Existing, on-site surface soil with the duff layer, if any, retained; and stockpiled on site and modified to produce viable planting soil, or imported, naturally formed or manufactured soil from off-site sources consisting of fertile, friable, naturally fine sandy loam, (USDA classification for soil consisting of 10-20 percent clay, 30-50 percent silt and 50-70 percent fine sand, particle 0.10-0.25 mm.) pH range of 5.5 to 7, 4 percent organic material minimum, and with sufficient structure to give good tilth and aeration
   1. Using preconstruction soil analyses and materials specified in other articles of this Section, amend existing, on-site surface soil to become planting soil complying with the requirements.
   2. For off-site sources, take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms or disease-causing plant pathogens.Soil shall not contain any noxious weeds or invasive plants, including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
   3. Planting Soil shall not include any of the following:
      a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
      b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand 1-inch or larger.
   4. Amend existing or imported soil with materials specified in other articles of this Section to become planting soil complying with the following requirements:

a. Particle Size Distribution by Separates:
    - Fine Sand: 50% to 70% percent by dry weight.
    - Silt: 30% to 50% percent by dry weight.
    - Clay: 10% to 20% percent by dry weight.
b. Percentage of Organic Matter: Minimum 4% by volume.
c. Soil Reaction: pH of 5.5 to 7 in accordance with pH range of plants specified.
d. CEC of Clay Fraction: Maximum 15 meq/100 mL at pH of 7.0.
e. Soluble-Salt Content: 5 to 10- dS/m measured by electrical conductivity.
f. RCRA Metals: Below maximum limits established by the EPA.
g. Phytotoxicity: Below phytotoxicity limits established by SSSA.

5. Acceptable ranges for base saturation percentages are:

Element	**Desired % Range**	**Ideal %**
Ca	60-70%	68%
Mg	10-20%	12%
K	2-5%	5%
Na	0.5-3%	0.75%
Other bases (variable)	2-4%	3.75%
Exchangeable Hydrogen	10-15%	10.5%

B. Unacceptable Properties
1. Clean soil of the following:
    a. Unacceptable Materials: concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, litter or other extraneous materials that are harmful to plant growth.
    b. Unsuitable Materials: stones 1-inche or larger in any dimension, noxious seeds, sticks, brush, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8% by dry weight of the imported soil.

2.2 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33/C33M.

G. Diatomaceous Earth: Horticultural diatomaceous earth, soil amendment grade.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
   1. Feedstock: Compost may be derived from: agricultural, food, or industrial residuals; biosolids (treated sewage sludge); yard trimmings; source-separated or mixed solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (< 1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived. Do not use compost that has received the addition of liming agents or ash by-products. The product shall be certified through the U.S. Composting Council's (USCC) Seal of Testing Assurance (STA) Program.
   2. Reaction: pH of 5.5 to 8
   3. Soluble-Salt Concentration: Less than 5 dS/m.
   4. Moisture Content: 35 to 55 percent by weight.
   5. Particle Size: 100 percent passing through a 1/2-inch sieve.
   6. The compost supplier shall test all compost products within 90 Calendar Days prior to application. Samples shall be collected using the Seal of Testing Assurance (STA) sample collection protocol. The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: (631) 737-4931, www.compostingcouncil.org.
      a. The sample shall be sent to an independent STA Program approved laboratory. The compost supplier shall pay for the test. A copy of the approved independent STA Program laboratory test report shall be submitted to the Landscape Architect prior to initial application of the compost. Seven days prior to application, the Contractor shall submit a sample of each type of compost to be used on the project to the Landscape Architect.
   7. Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall be immediately removed from the project and replaced at no cost to the Owner.
   8. The Contractor shall submit the following information to the Landscape Architect for approval:
      a. The supplier shall verify in writing and provide lab analyses that the Materials comply with the processes, testing, and standards specified in these Specifications. An independent STA Program certified laboratory shall perform the analysis.
      b. A copy of the producer's STA certification as issued by the U.S. Composting Council.

2.4 FERTILIZERS

A. As required by soil analysis and recommendations.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

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

D. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff of airborne dust to adjacent properties and walkways.

3.2 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil, or apply manufactured soil on site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 4 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 2 inches of subgrade. Spread remainder of planting soil.

C. Mixing: Spread unamended soil to total depth indicated on Drawings, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
   1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

a. Mix lime and sulfur with dry soil before mixing fertilizer.
b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.3 PROTECTION

A. Protection Zone: Identify protection zones as indicated on Drawings.

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is over-compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Landscape Architect and replace contaminated planting soil with new planting soil.

3.4 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
1. Legally dispose of excess subsoil and unsuitable materials off-site.

END OF SECTION 329113

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SECTION 329200
TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Seeding.
   2. Sodding.
   3. Turf renovation.
   4. Erosion-control materials.

B. Related Requirements:
   1. Section 329113 Soil Preparation for information regarding planting soils.
   2. Section 329300 Plants for trees, shrubs, ground covers, and other plants.

1.3 REFERENCES

A. Association of Official Seed Analysts (AOSA) “Rules for Testing Seeds.”

B. Turfgrass Producer’s International (TPI) “Guideline Specifications to Turfgrass Sodding.”

1.4 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Invasive Plant/Species: Plant that is non-native to the ecosystem under consideration and whose presence causes or is likely to cause environmental, economic, or human harm.

C. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

E. Planting Soil: Existing, on-site soil; imported soil or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 Soil Preparation and drawing designations for planting soils.

F. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. At conference, Landscape Contractor and General Contractor shall review Owner's current edition of integrated pest management plan.

1.6 ACTION SUBMITTALS

A. Planting & Installation Schedule: Submit proposed planting and installation schedule, indicating dates for completion of work items, soil testing, and installation of each type of turfgrass during normal seasons for such work in area of site.
   1. Correlate Plant & Installation Schedule with specified maintenance periods to provide maintenance from date of Substantial Completion. Once accepted, revise dates only as approved in writing, after documentation of reasons for delays.
   2. Submit letter notifying General Contractor and Landscape Architect of completion of planting work and requesting inspection to determine acceptability for Substantial Completion and beginning of Warranty Period.
   3. Submit letter to General Contractor and Landscape Architect requesting a final inspection of planting work for Final Acceptance at end of Warranty Period.

B. Turf and/or Plant Maintenance Schedule: Depending on Project conditions, submit proposed turf maintenance (and/or plant maintenance for seeded non-turf areas), indicating frequency of maintenance visits and scheduled maintenance activities to occur during visits. See Part 3 for more information on required Turf/Plant Maintenance activities.
   1. Turf/Plant maintenance schedule shall be specific to distinct planting conditions on site. Examples of planting conditions are project specific and may include, but are not limited to:
      a. Seeded Turfgrass areas.
      b. Sodded Turfgrass areas.
      c. Seeded non-turf areas (such as Meadows, swales, bio-retention areas, etc.)
   2. At a minimum, Turf/Plant Maintenance Schedule shall include:
      a. Weekly maintenance visits and description of maintenance activities for each planting area.
      b. Weeding and invasive species control and removal practices.
      c. Watering schedule and practices.
      d. Tools to be used for maintenance.
      e. Timing of initial and second cuttings of seeded non-turf areas.
      f. Timing of Turf Postfertilization.

g. Timing of Turf Aeration.

3. As part of Turf/Plant Maintenance schedule, Work Logs shall be submitted to Owner on a weekly basis. See Part 3 for more information.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Landscape Contractor.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Landscape Contractor shall submit Certification of Grass Seed as part of project submittals and provide Certification of Grass Seed to General Contractor and upon delivery to Project Site. Grass seed delivered to Project Site without proof of Certification or Certification that is different from approved submittal will be rejected and immediately removed from the site.

C. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

1. Landscape Contractor shall submit Certification of Seed mixture for sod as part of project submittals and provide Certification of Seed mixture for sod to General Contractor upon delivery to Project Site. Sod delivered to Project Site without proof of Certification or Certification that is different from approved submittal will be rejected and immediately removed from the site.

D. Product Certificates: For fertilizers, from manufacturer.

E. Pesticides and Herbicides: Applicator License number and product label and manufacturer's application instructions specific to Project and in accordance with Owner’s integrated pest management practices.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner’s for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.9 QUALITY ASSURANCE

A. Landscape Contractor Qualifications: A qualified Landscape Contractor whose work has resulted in successful turf establishment.

1. Professional Membership: Landscape Contractor shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.

2. Experience: Engage an experienced Installer who has completed turf installation to the extent indicated for this Project and with a record of successful lawn establishment for a minimum of three (3) years.
3. Landscape Contractor's Field Supervision: Require Landscape Contractor to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Pesticide Applicator: State-licensed, commercial.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in Turfgrass Producers International (TPI) "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

1.11 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion. Planting windows shall be reviewed at start of construction and may be adjusted depending on climate conditions (average seasonal temperatures, annual rainfall, and significant weather events) in the year of planting. Seeding or sodding not within these periods noted below requires approval in writing from Landscape Architect.
1. Seeding:
    a. Spring Planting: March 15 – May 31
    b. Fall Planting: August 15 – November 15
2. Sodding:
    a. Spring Planting: March 1 – May 31
    b. Fall Planting: September 1 – November 15

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.12 MAINTENANCE SERVICE

A. Maintenance Service Turf: Provide maintenance by skilled employees of Landscape Contractor. Maintain as required in Part 3 and per approved Turf Maintenance schedule. Begin maintenance activities immediately after each area is planted and continue until acceptable turf is established, but not for less than the following periods beginning from date of Substantial Completion and acceptance of Work for the entire project by Owner:
   1. Seeded Turf: Ninety (90) days from date of Substantial Completion of entire project.
      a. When initial maintenance period has not elapsed before end of planting season, or turf is not fully established, continue maintenance during next planting season.
   2. Sodded Turf: Thirty (30) days from date of Substantial Completion of entire project.
      a. When initial maintenance period has not elapsed before end of planting season, or turf is not fully established, continue maintenance during next planting season.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species for Turf Lawns:
   1. Quality, State Certified: State-certified seed of grass species as listed below for solar exposure.
   2. The seed mixes provided below are for reference purposes only for Full Sun, Sun and Partial Shade, and Shade conditions. Seed mixes shall be project specific and may differ from composition below.
   3. Full Sun, Cool-Season Grass: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
   4. Sun and Partial Shade: Cool-Season Grass Mixture, proportioned by weight as follows:
      a. 50 percent Kentucky bluegrass (*Poa pratensis*).
      b. 30 percent chewings red fescue (*Festuca rubra* variety).
      c. 10 percent perennial ryegrass (*Lolium perenne*).
      d. 10 percent redtop (*Agrostis alba*).
   5. Shade, Cool-Season Grass: Proportioned by weight as follows:
      a. 50 percent chewings red fescue (*Festuca rubra* variety).
      b. 35 percent rough bluegrass (*Poa trivialis*).
      c. 15 percent redtop (*Agrostis alba*).
   6. Other seed mixtures as approved by Landscape Architect and Owner.

C. Seed Species for Non-Turf Areas (Meadows, Bio-retention areas, Swales or Other Planting Areas)
   1. Quality, State Certified: State-certified seed of grass species.

2. Proprietary or Custom Seed Mix specified by species and cultivars and approved by Landscape Architect and Owner.

2.2 TURFGRASS SOD

A. Turfgrass Sod: Certified, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. The sod species provided below are for references purposes only for Full Sun, Sun and Partial Shade, and Shade conditions. Sod shall be project specific and may differ from recommendations below.
   1. Turfgrass Species, Cool-Season Grass: Sod of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
   2. Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
   3. Sun and Partial Shade: Proportioned by weight as follows:
      a. 50 percent Kentucky bluegrass (*Poa pratensis*).
      b. 30 percent chewings red fescue (*Festuca rubra* variety).
      c. 10 percent perennial ryegrass (*Lolium perenne*).
      d. 10 percent redtop (*Agrostis alba*).
   4. Shade: Proportioned by weight as follows:
      a. 50 percent chewings red fescue (*Festuca rubra* variety).
      b. 35 percent rough bluegrass (*Poa trivialis*).
      c. 15 percent redtop (*Agrostis alba*).
   5. Other sod mixture as approved by Landscape Architect and Owner.

2.3 SOIL AMENDMENTS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition:
      a. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition:
      a. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

C. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.

D. See Section 329113 Soil Preparation, for soil testing requirements. Application of Soil Amendments shall be per Pre- and Post-Construction soil testing recommendations.

2.4 PLANTING SOIL

A. See Section 323913 Soil Preparation.

2.5 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley. Do not use field hay as it may contain weed seeds.

2.6 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for specific project conditions, and in accordance with Owner's Integrated Pest Management Plan and practices. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.7 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

B. Silt Sock: Tubular shaped erosion and sediment control device comprised of a biodegradable fabric exterior filled with all natural wood fiber.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

3. Uniformly moisten excessively dry soil that is not workable, or which is dusty.
4. Verify there are no invasive plants present in the area to be planted. If present, invasive plants shall be removed prior to plant installation.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Landscape Architect and replace with new planting soil.

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

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
1. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils, discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, and to separate seeded areas from other planting areas.

C. Clean all tools, equipment, and work materials prior to beginning work each day to prevent spread of diseases or contamination.

3.3 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 Soil Preparation.

B. Newly Graded Subgrades: Loosed subgrade to a minimum depth of 8-inches. Remove stones larger than 1-1/2-inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
1. Spread planting soil to a depth of 6-inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
a. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least 6-inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6-inches of soil. Till soil to a homogeneous mixture of fine texture.
3. Remove stones larger than 1-1/2-inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2-inch of finish elevation. Roll and

rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For erosion-control blanket, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

C. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Where two or more different seed mixes are adjacent or seed mix is adjacent to sod or other planting areas, install silt sock at boundary of seed mix(es) to prevent seed migration between seeded and/or planted areas. Dig in silt sock at seeding boundary so top of silt socks is min. 6” above finished grade. Silt sock shall be removed at end of Maintenance Period as identified in Part 1.
   1. Landscape Contractor shall dig in and stake silt sock on slopes exceeding 1:6. Stakes shall be installed per manufacturer’s recommendations at a spacing no greater than 10’.

3.5 SEEDING

A. Sow seed using cultipacker type spreading machine, unless otherwise approved by Landscape Architect and Phila. Do not drop seed when wind velocity exceeds 5 mph.
   1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   2. Do not use wet seed or seed that is moldy or otherwise damaged.
   3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at recommended rate based on seed mix.

C. If directed by Landscape Architect or Owner, rake seed lightly into top 1/8-inch of soil, roll lightly, and water with fine spray.

D. Seeding of slopes greater than 1:4 is not permitted, unless authorized by Owner. See 3.6 Sodding for more information.

E. Protect seeded areas with slopes between 1:6 and 1:4 with erosion control fiber mesh installed and stapled according to manufacturer's written instructions.

F. Protect seeded areas with slopes less than 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2-inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
   1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

G. Protect all seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16-inch**,** and roll surface smooth.

3.6 SODDING

A. Lay sod within 24 hours of harvesting unless a suitable preservation method is accepted by Landscape Architect prior to delivery time. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
   1. Lay sod across slopes at or exceeding 1:4.
   2. Anchor sod on slopes exceeding 1:6 with anchors as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2-inches below sod.

3.7 TURF RENOVATION

A. Renovate existing turf where indicated or where existing turf is damaged due to construction activities.

B. Renovate turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
   1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
   2. Install new planting soil as required.

C. Remove sod and/or seed and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

D. Remove topsoil containing foreign materials, such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

E. Mow, dethatch, core aerate, and rake existing turf.

F. Remove all weeds and/or invasive plants before seeding. Where weeds or invasive species are present, submit procedures for invasive plant or weed removal for review and approval by Owner prior to removal activities. Selective herbicides may only be used in in accordance with Owner's integrated pest management plan and only with written approval of Owner. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6-inches.

I. Apply soil amendments and initial fertilizer required for establishing new turf and mix thoroughly into top 4-inches of existing soil. Install new planting soil to fill low spots and meet finish grades.
   1. Soil Amendment(s): Apply soil amendment(s) according to requirements of Section 329113 Soil Preparation.
   2. Initial Fertilizer: Slow-release fertilizer applied according to manufacturer's recommendations.

J. Apply seed and protect with straw mulch and sod as required for new turf.

K. Water newly planted areas and keep moist until new turf is established.

3.8 TURF AND PLANT MAINTENANCE

A. General: Maintain and establish turf and seeded areas by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf or plantings. Roll, regrade, and replant bare or eroded areas and re-mulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

B. Record all maintenance activities in a Work Log. Landscape Contractor's personnel shall submit Work Logs upon completion of each turf maintenance visit to Owner. Work Logs shall include time and date of Work, number of hours spent at the site, and a description of maintenance tasks performed during the maintenance visit, in addition to other items listed in Specifications.
   1. Notify Owner at least 48 hours prior to each Maintenance visit.

C. Regular Turf and Plant Maintenance Activities: At a minimum, perform the following activities during each Turf and/or Plant Maintenance visit.

1. Watering: Loss of turf or plants due to inadequate watering will be considered negligence of maintenance services and will require replacement at no cost to Owner. A watering plan shall be submitted as part of Action Submittals.
    a. Watering Frequency: Water all newly seeded or sodded areas with fine spray at a minimum rate of 1-inch per week, unless greater than 1-inch of precipitation has occurred at Project site within previous 7 days. If maintenance personnel elects not to perform watering due to previous precipitation, documentation must be provided to Owner showing amount of precipitation on site for past 7 days.
        1) Contractor may install and maintain temporary piping, hoses, and/or turf-watering equipment to convey water from approved sources and keep turf or planting area uniformly moist to a depth of 4-inches.
    b. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
    c. Watering activities and timeframes shall be recorded in Work Logs.
2. Maintain an invasive plant and weed-free installation. Invasive plants and weeds shall be removed as part of regular maintenance activities throughout duration of Turf Maintenance period. If weeds or invasive species are observed, submit procedures for invasive plant and weed removal for review and approval by Owner prior to removal activities. Identify invasive species and record removal procedures within Work Logs.
3. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
4. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
5. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Follow Owner's integrated pest management practices to minimize the use of pesticides and reduce hazards.
6. Mow turf as soon as top growth is tall enough to cut. Lawn mowing shall occur on a regular basis, typically weekly unless conditions do not permit. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Ensure mower blades are sharp and provide a clean cut. Schedule initial and subsequent mowings to maintain the following grass height:
    a. Mow to a height of 3 to 3.5-inches.
    b. If using a mulching mower, lawn clippings may be left on the lawn to decompose.
7. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.
    a. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.
8. Turf Aeration: Aerate lawn prior to end of Maintenance period.

D. For seeded areas that are not turfgrass (such as Meadows and bio-retention areas), cut back grasses early in the season when vegetation reaches 12-inches in height to a height

of 6-inches. Return and cut back when vegetation reaches 12-inches in height to a height of 8-inches.

3.9 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Landscape Architect or Owner:
   1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
   2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.10 PESTICIDE APPLICATION

A. Herbicides and other chemical products ***shall not*** be applied unless specifically approved in writing by Owner in accordance with Owner's integrated pest management practices.
   1. Herbicides and other chemical products shall only be applied by a Licensed Applicant and shall not occur without approval by Owner.

B. Notify Owner before each application is performed.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.11 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures and silt socks between seed mixes or sod at end of grass establishment period. Repair any plant beds or lawns damaged as a result of erosion control measure removal.

END OF SECTION 329200

SECTION 329300
PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Trees (Understory).
   2. Shrubs.
   3. Fertilizers.
   4. Mulches.
   5. Tree Watering Bags.

B. Related Requirements:
   1. Section 329113 "Soil Preparation" for information regarding planting soil.
   2. Section 329200 "Turf and Grasses" for turf (lawn).

1.3 REFERENCES

A. American National Standards Institute (ANSI):
   1. Z60.1 – American Standards for Nursery Stock
   2. A300 – Standards for Tree Care Operations

B. United States Department of Agriculture (USDA):
   1. Plant Hardiness Zone Map

C. American Society for Testing and Materials (ASTM) Standards as listed in Specification.

1.4 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than sizes indicated; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball

when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

D. Finish Grade: Elevation of finished surface of planting soil.

E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

F. Planting Area: Areas to be planted.

G. Planting Soil: Imported soil or manufactured soil that has been modified with soil amendments and/or fertilizers to produce a soil mixture best for plant growth. See Section 329115 "Soil Preparation (Performance Specification)" for drawing designations for planting soils.

H. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

I. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

J. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

K. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.5 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Plant Materials: Contractor shall provide a confirmed Plant Schedule verifying quantities, sizes, quality, and sources for all specified plant materials.
      a. Contractor shall provide confirmed Plant Schedule to Landscape Architect a minimum of six (6) weeks prior to anticipated Plant Installation.
   2. Plant Photographs: For plant material not tagged in field by Landscape Architect, include color photographs in digital format of each required species and size of

plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 10 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

a. Landscape Architect reserves the right to reject plant material based on photographs that do not meet specification requirements or appear damaged, diseased, or otherwise unhealthy.

B. Samples for Verification: For each of the following:
   1. Plant Material: Bill of sale indicating full scientific name, quantity, plant size, and name of growing nursery for all plant material.
   2. Organic and Compost Mulch: 1-quart (1-L) volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.

C. Planting & Installation Schedule: Submit proposed planting and installation schedule, indicating dates for completion of work items, plant tagging, soil testing, digging of woody plants, and installation of each type of landscape work during normal seasons for such work in area of site.
   1. Correlate Plant & Installation Schedule with specified maintenance periods to provide maintenance from date of Substantial Completion. Once accepted, revise dates only as approved in writing, after documentation of reasons for delays.
   2. Submit letter notifying Owner and Landscape Architect of completion of planting work and requesting inspection to determine acceptability for Substantial Completion and beginning of Warranty Period.
   3. Submit letter to Owner and Landscape Architect requesting a final inspection of planting work for Final Acceptance at end of Warranty Period.

D. Plant Maintenance Schedule: Submit proposed plant maintenance schedule, indicating frequency of maintenance visits and scheduled maintenance activities to occur during visits.
   1. Plant maintenance shall include watering of plants. Loss of plants due to inadequate watering will be considered negligence of maintenance services and will require plant replacement at no cost to Owner.
   2. A one-year watering plan shall be submitted as part of Plant Maintenance Schedule.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
2. Experience: Engage an experienced Installer who has completed planting work similar in material, design, and extent to that indicated for this Project and with a record of successful plant establishment for a minimum of three (3) years.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Pesticide Applicator: State-licensed, commercial.

B. Nursery Qualifications: A nursery specializing in growing and cultivating the plant specified in this Section with a minimum of six (6) years' experience.
1. Nurseries shall be members of the American Association of Nurserymen and Pennsylvania Landscape and Nurserymen's Association, or equivalent State organization(s).
2. Nurseries shall be within same plant hardiness zone and having similar climate conditions as Project Site. Zone shall be as defined on United States Department of Agriculture Plant Hardiness Zone Map.
    a. Nursery shall be located within 75-miles of Project site. Plant sources greater than this distance will not be accepted without written approval by Landscape Architect.

C. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

D. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for

height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

E. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality.

1. Landscape Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
2. Notify Landscape Architect of sources of planting materials at least seven days in advance of delivery to site.

F. Substitutions: Substitutions will only be considered after review of plant availability with Landscape Architect. Submit request for substitutions in writing to Landscape Architect. **Substitutions will only be accepted with written approval by Landscape Architect.**

1.10 HARVESTING, DELIVERY, STORAGE, AND HANDLING

A. Tree Tagging: Landscape Architect may accompany Contractor to nursery to select and tag trees. Landscape Architect may choose to select and tag shrubs.

1. Landscape Architect shall select plants for proper visual formation. Contractor shall inspect selected plants for disease and other requirements of Contract Documents. Prior to nursery trip, Contractor shall have pre-selected Nursery(s) to ascertain the sufficient plants in size and species required, and provided the confirmed Plant Schedule to Landscape Architect.
2. The Landscape Architect may tag trees and shrubs of each species as a representative sample. Trees and shrubs delivered to the Project site without tags, and shrubs that do not equally match the quality of tagged samples, shall be rejected.

B. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their

natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. The Contractor must verify that one of the following methods is used to protect plant material in transit:
   1. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
      a. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
   2. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

G. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
   1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   2. Do not remove container-grown stock from containers before time of planting.
   3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

H. All plant material must have labels showing botanical name on each individual plant. Plants without labels will rejected by Landscape Architect and shall be removed immediately from the Project Site.

I. Notify the Landscape Architect at least three (3) business days in advance of start of Work.

J. The Landscape Architect reserves the right to reject plant materials not meeting the above requirements.

1.11 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work. Hand excavate, as required. Maintain grade stakes until parties concerned mutually agree upon removal.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: March 15 – June 15
2. Fall Planting: September 1 – November 15
3. Planting outside of designated timeframes above may only occur with written approval from Landscape Architect.
4. Planting between June 16 to August 31 is not permitted.

C. Plant trees after finished grades are established and before planting lawns, unless approved otherwise by Landscape Architect.
   1. When planting trees after lawn, protect lawn areas and promptly repair damage caused by planting operations.

D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

E. Utilities: Determine location of above-grade and underground utilities and perform Work in a manner which will avoid damage. Hand excavate, as required. Maintain grade stakes until parties concerned mutually agree upon removal.
   1. Notify Owner no fewer than three (3) days in advance of proposed interruption of each service or utility.
   2. Do not proceed with interruption of services or utilities without Owner’s written permission.

F. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or other obstructions, notify Landscape Architect before planting.

1.12 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Death and unsatisfactory growth, including resulting from lack of adequate maintenance during warranty period.
      b. Structural failures including plantings falling or blowing over.
      c. Faulty performance of tree stabilization edgings and tree grates.
      d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Periods: From date of Substantial Completion and acceptance of Work by Owner.
      a. Trees, Shrubs, Vines, and Ornamental Grasses: Twelve (12) months.
      b. Ground Covers, Biennials, Perennials, and Other Plants: Twelve (12) months.
   3. Include the following remedial actions as a minimum:
      a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.

b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
d. Provide extended warranty for period equal to original warranty period, for replaced plant material.
e. At end of Warranty Period, cut bindings around base of trunks and remove loose materials. Redistribute, add, and/or replace mulch as needed.

1.13 MAINTENANCE SERVICE

A. Initial Maintenance Service for Plant Material. Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptable healthy and well-established but not for less than maintenance period below:
1. Maintenance Period for Trees and Shrubs: Twelve (12) months.
2. Ground Covers, Perennials, Ornamental Grasses, and Other Plants: Twelve (12) months.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable and will be rejected and shall be removed from the project site immediately.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
3. Acquire plants from nurseries within 100-mile radius of Project Site. Plant sources greater than this distance will not be accepted without written approval from Landscape Architect.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.
   1. Plants without labels will be rejected by Landscape Architect and shall be removed immediately from the Project Site.

2.2 TREES

A. Provided balled and burlapped trees, unless container-grown trees are specified on Plant Schedule.

B. Canopy Trees: Provide canopy trees with well-balanced crowns, straight trunks with intact main leaders, undamaged and uncut, and of height and caliper indicated on Plant Schedule, and conforming to ANSI Z60.1.
   1. Tree sizes and conditions shall meet or exceed requirements as specified on Plant Schedule. Contractor may elect to provide trees with larger caliper than specified at no additional cost to Owner.

C. Understory Trees: Provide understory trees that are upright and spreading, branched naturally according to species and type, and of height and container size indicated on Plant Schedule, and conforming to ANSI Z60.1.
   1. Understory trees shall have two to three main stems. Understory trees with four or more main stems may be rejected upon inspection by Landscape Architect.

2.3 SHRUBS

A. Provide deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub. See Plant Schedule.

2.4 FERTILIZERS

A. Feeder Packs: Organic, biodegradeable packs containing a measured dose of fertilizer (4-2-2), mycorrhizae, biochar, azomite, and micronized oyster shell (5% calcium and 1% Sulphur).
   1. *Fuhgeddaboudit!* Root Zone Feeder Packs, manufactured by Organic Mechanics Soil Company, LLC
      P.O. Box 272, Modena, PA 19358
      Phone: 610-380-4598
      www.organicmechanicsoil.com

2.5 PLANTING SOIL

A. See Section 323913 “Soil Preparation.”

2.6 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of the following:
   1. Type: Triple-Shredded hardwood bark.
   2. Size Range: 3-inch maximum, 1/2-inch minimum.
   3. Color: Natural and undyed.

B. Leaf Litter: Chopped or shredded leaves, free of weeds, seeds, loam, sand, clay, and other foreign substances. Acquire leaf litter locally from a source approved by Landscape Architect.

2.7 TREE-WATERING BAGS

A. Slow-Release Watering Bags: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic. Obtain from source below or approved equal.
   1. Treegator Original, manufactured by Spectrum Products, Inc.
      153 Mosswood Boulevard, Youngsville, NC 27596
      Phone: 1-866-873-3428
      www.treegator.com

2.8 MISCELLANEOUS PRODUCTS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

B. Burlap: Non-synthetic, biodegradable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.

2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

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

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."

B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade.

C. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Around Existing Trees:
1. Loosen existing soil surface by hand to a depth required to plant shrubs and / or herbaceous plants.
2. Do not place more than 10” of planting soil under dripline of existing trees.
3. Spread two-inch deep layer of compost over soil. Mix thoroughly into top six inches of soil. Excavate and remove existing soil as required to maintain existing grades of landscape beds.

E. Newly Graded Subgrades:
1. Loosen compacted subgrade with a subsoil ripping tool to a depth of 18-inches and with vertical trenches 24-inches apart. Run subsoil-ripping tool in two directions at right angles to each other.

2. Spread 2-inch-deep layer of topsoil or planting mix over loosened subgrade. Mix thoroughly into top 4-inches of subgrade.
3. Spread topsoil or planting mix to depths indicated, but not less than required, to meet finish grades after addition of amendments, light rolling, and natural settlement. Do no spread if topsoil or subgrade is frozen, muddy, or excessively wet. Apply soil amendments and fertilizer on surface and mix thoroughly into topsoil.
4. Spread 2-inch-deep layer of compost over topsoil. Mix thoroughly into top 6-inches of soil.
5. After light rolling and settlement, compact in 6-inch lifts and compact to 85% of maximum dry weight according to ASTM D698, to depth required to meet grades and elevations as indicated on Drawings.

F. Finish Grade: Grade planting beds to a smooth, even surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
1. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

G. Stage installation of topsoil or planting mix to avoid travel by equipment over placed topsoil or planting mix.

H. Restore planting beds if eroded or otherwise disturbed

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.
1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Scarify subgrade 2-inches, and trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter for balled and burlapped and container-grown stock.
3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
7. Maintain supervision of excavations during working hours.
8. Keep excavations covered or otherwise protected after working hours or when unattended by Installer's personnel.

B. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

C. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

3.5 TREE AND SHRUB PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with top of root ball at same elevation relative to ground level as in the nursery.
   1. If soil is dry, moisten prepared planting areas before planting. Do not create muddy soil conditions.
   2. Backfill: Approved planting soil.
   3. Do not remove burlap from balls. After placing some backfill around root ball to stabilize plant, carefully cut and remove rope and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   4. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   5. Place fertilizer feeder packs equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball per manufacturer's instructions.
      a. Quantity: Three (3) per canopy and understory tree.
   6. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with top of root ball level with adjacent finish grades of planting soil.
   1. Backfill: Approved planting soil.
   2. Carefully remove root ball from container without damaging root ball or plant.
   3. Cut pot bound foots to prevent future root girdling.
   4. Place stock on setting layer of compacted planting soil.
   5. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   6. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball per manufacturer's instructions.
      a. Quantity: One (1) per shrub.
   7. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE AND SHRUB PRUNING

A. Remove only dead, dying, or broken branches. Do not prune otherwise unless directed by Landscape Architect

B. Do not cut tree leaders unless directed by Landscape Architect.

C. Do not apply pruning paint to wounds.

3.7 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees in Turf Areas: Apply organic mulch ring of 1-1/2” thick layer of leaf litter, followed by 1-1/2” thick layer of triple-shredded hardwood mulch on top of leaf litter layer, with 18-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
   2. Planting Areas: Apply 1-1/2” thick layer of leaf litter, followed by 1-1/2” thick layer of triple-shredded hardwood mulch on top of leaf litter layer, over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.8 INSTALLATION OF TREE WATERING BAGS

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

3.9 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical

controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

D. Plant maintenance shall include watering of plants. Loss of plants due to inadequate watering will be considered negligence of maintenance services and will require plant replacement at no cost to Owner. A one-year watering plan shall be submitted as part of Plant Submittals.
   1. Install and maintain temporary drip irrigation piping and hoses to convey water from sources to planting areas and to keep plantings uniformly moist.

E. Fertilize trees approximately one year after installation between October and December, or between February and April. Unless otherwise indicated by soil test results, apply at a rate of 2 pounds of actual nitrogen per 1,000 square feet. Make insertion points approximately 2'-6" apart, at a depth of 6 inches. Apply fertilized in the ball and backfill area, and to approximately 1 foot outside of the planting hole.\

3.10 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Landscape Architect.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Landscape Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition or are damaged during construction operations that Landscape Architect determines are incapable of restoring to normal growth pattern.
   1. Provide new trees of same size and species as those being replaced for each tree unless otherwise directed by Landscape Architect.

3.11 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.12 FINAL INSPECTION

A. Inspection to determine completion and acceptance of planted areas will be made by the Landscape Architect, upon Contractor's request. Provide notification at least ten (10) business days before requested inspection date. Inspection comments will be submitted to the Contractor in writing.

B. Planted areas will be accepted provided all requirements, including the maintenance period have been complied with and plant materials are alive and in a healthy, vigorous condition.

C. Upon acceptance of Work, the Owner will assume plant maintenance and the plant material Warranty period will begin.

D. An additional inspection will be made near the end of the Warranty period to determine if plant materials need to be replaced. Plants shall be in a health, vigorous growing state and free of disease and insects.

END OF SECTION 329300

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