Engineering Exhibit C
Specifications – Volume 2
Bid Documents

City of Madison
Metro Transit
Service Lane Addition

Mead & Hunt, Inc.
4503500-170148.02

Contract No. 8238
Munis No. 11228

Prepared for:

City of Madison
Metro Transit
Madison, Wisconsin

Prepared by:

Mead & Hunt

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SECTION 21 90 00
WATER BASED FIRE SUPPRESSION 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 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Fire suppression system piping designed to operate at working pressure of 175 psig maximum.

B. Fire Protection Engineer (FPE): Qualifications of the Fire Protection Engineer, with license number, shall be submitted to and approved by the Engineer prior to submission of the show drawings. For the purposes of these specifications, the FPE shall have one of the following qualifications:

1. The FPE shall be a registered Professional Engineer (PE), who has passed the National Council of Examiners for Engineering and Surveys (NCEES) written examination in fire protection engineering. OR
2. The FPE shall be a registered Professional Engineer who is regularly engaged in the design of fire protection systems. OR
3. The FPE shall have Level III certification for water-based fire protection systems layout, plus a minimum of 5 years of work experience in fire protection engineering.
4. The FPE shall have Level IV certification for complex fire protection systems layout, plus a minimum of 5 years of work experience in fire protection engineering.

C. NFPA: National Fire Protection Association

D. DG: Design Guide

1.3 SYSTEM DESCRIPTIONS

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

B. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. A dry valve separates the piping from a water supply. Sprinklers open when heat melts a fusible link or destroys a frangible device. Compressed air discharges immediately from sprinklers when they are opened. The reduced air pressure allows the dry valve to open. When the dry valve opens, water travels to the open sprinklers and then discharges from the open sprinklers. Hydraulic and electric sensors send alarms when water flows.

1.4 PERFORMANCE REQUIREMENTS

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

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by an FPE, using performance requirements and design criteria indicated.

1. Available fire-hydrant flow test records indicate the following conditions:

   a. Date: July 24th, 2018
   b. Static Pressure: 86 psig.
   c. Measured Flow: 2000 gpm.
   d. Residual Pressure: 79 psig.

2. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
3. Specific sprinkler design parameters shall be per drawings and per NFPA 13.
4. Specific standpipe design parameters shall be per drawings and per NFPA 14.
5. Maximum Protection Area per Sprinkler: Per UL listing.

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

1.5 SUBMITTALS

A. For each item indicated, to be submitted prior to start of construction.

B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified FPE responsible for their preparation. Design documents shall include the features indicated in NFPA 13, which include but are not limited to:

1. Piping layout, including risers.
2. Valve and sprinkler locations.
3. Drains and drain outlet locations.
4. Hydraulically most remote area and sprinkler density.
5. Hydraulic node locations.
6. Hydraulic calculations for hydraulically most remote area, including pressures at hydraulic nodes and each sprinkler.
7. Installation details.
8. Flow and tamper switch locations.

D. Fire-Hydrant Flow Test Report: Report shall contain data including, but not limited to:

1. Full name of person who performed the test.
2. Full name of persons who witnessed the test.
3. Date of the test.
4. Static pressure.

5. Flow rate, and corresponding residual pressure when stated flow rate occurred.
6. Sketch indicating site location of hydrants used for test.
7. FPE shall witness or perform the flow test. Flow tests not witnessed or performed by the FPE shall not be used.

E. Qualification Data: For qualified Installer and FPE.

1. Submit the name and documentation of certification of the proposed FPE, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations.

F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable. Contractor shall submit plans to AHJ for review per AHJ requirements.

G. Final acceptance test plan. Plan shall include all tests to be performed, and the performance level required to pass each test. Required tests shall verify proper operation of all subsystems, including but not limited to:

1. Fire alarm.
2. Electrical power.
3. Mechanical.
4. Plumbing.
5. Controls.

1.6 CLOSEOUT SUBMITTALS

A. For each item indicated, to be submitted within 30 days of substantial completion of construction. All submittals shall be delivered to Owner 30 days prior to proposed scheduled final acceptance of system.

B. Welding certificates, if field welding was performed.

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

D. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

E. Record Drawings: Submit drawings showing sprinkler system as installed. Drawings shall be stamped with FPE seal indicating FPE has inspected and approved installation. Drawings shall include, but are not limited to, all features included in the Delegated-Design Submittal.

1.7 QUALITY ASSURANCE

A. 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.

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

1. NFPA 13, "Installation of Sprinkler Systems."

a. Exception: Welded stainless steel pipe may be used.

2. NFPA 14, “Installation of Standpipe and Hose Systems.”
3. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."
4. NFPA 409 “Standard on Aircraft Hangars.”
5. NFPA 415 “Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways.”

D. ASCE/SEI 7, “Minimum Design Loads for Buildings and Other Structures.”

E. ANG ETL 15-01, “Air National Guard Design Policy”

F. DOD UFC 3-600-01, “Fire Protection Engineering for Facilities”

1.8 PROJECT CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Owner's written permission.

1.9 COORDINATION

A. Coordinate layout and installation of sprinkler systems with other construction, including but not limited to light fixtures, HVAC equipment, and partition assemblies.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 STEEL PIPE AND FITTINGS

A. Schedule 40, Galvanized-Steel Pipe: ASTM A 53/A 53M, Schedule 40.

B. Thin wall Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, with wall thickness less than Schedule 40 and equal to or greater than Schedule 10.

C. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10, plain end.

D. Schedule 40 stainless steel pipe with buttweld fittings. Note: Stainless steel is not an approved material per NFPA 13. Contractor shall obtain an equivalency from the AHJ to allow the use of stainless steel pipe and fittings.

E. Ferrous fittings per NFPA 13.

F. Listed ferrous, rubber-gasketed pipe fittings per NFPA 13.

G. Grooved-Joint, Steel-Pipe Appurtenances:

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

    a. Anvil International, Inc.
    b. Tyco Fire & Building Products LP.
    c. Victaulic Company.

2. Pressure Rating: 300 psig minimum.
3. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

H. Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

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

    a. Victaulic Company.

2.3 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating: 175 psig.

B. Ball Valves:

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

    a. Conbraco Industries, Inc.; Apollo Valves.
    b. Hammond Valve.
    c. Milwaukee Valve Company.
    d. NIBCO INC.
    e. Watts; a Watts Water Technologies company.

2. Description:

    a. Standard: MSS SP-110.
    b. CWP Rating: 300 psig

C. Iron Butterfly Valves:

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

    a. Anvil International.
    b. Milwaukee Valve Company.
    c. NIBCO INC.
    d. Tyco Fire & Building Products LP.
    e. Victaulic Company.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig.
4. Body Material: Cast or ductile iron.
5. End Connections: Lug or Grooved.

D. Check Valves:

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

    a. Anvil International.
    b. Milwaukee Valve Company.
    c. NIBCO INC.
    d. Tyco Fire & Building Products LP.
    e. Victaulic Company.
    f. Viking Corporation.
    g. Watts; a Watts Water Technologies company.

2. Standard: UL 312.
3. Pressure Rating: 300 psig.
4. Type: Swing check.
5. Body Material: Cast iron.
6. End Connections: Flanged or grooved.

E. Bronze OS&Y Gate Valves:

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

    a. Milwaukee Valve Company.
    b. NIBCO INC.

2. Standard: UL 262.
3. Pressure Rating: 175 psig.
4. Body Material: Bronze.
5. End Connections: Threaded.

F. Iron OS&Y Gate Valves:

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

    a. Hammond Valve.
    b. Milwaukee Valve Company.
    c. NIBCO INC.
    d. Tyco Fire & Building Products LP.
    e. Watts; a Watts Water Technologies company.

2. Standard: UL 262.
3. Pressure Rating: 300 psig.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

G. Indicating-Type Butterfly Valves:

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

    a. Anvil International.
    b. Milwaukee Valve Company.
    c. NIBCO INC.
    d. Tyco Fire & Building Products LP.
    e. Victaulic Company.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig minimum.
4. Valves NPS 2 and Smaller:

    a. Valve Type: Ball or butterfly.

b. Body Material: Bronze.
c. End Connections: Threaded.

5. Valves NPS 2-1/2 and Larger:

a. Valve Type: Butterfly.
b. Body Material: Cast or ductile iron.
c. End Connections: Flanged, grooved, or wafer.

6. Valve Operation: Integral supervisory switch.

2.4 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:

a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Double-Check, Backflow-Prevention Assemblies:

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

a. Conbraco Industries, Inc.
b. FEBCO.
c. Watts; a Watts Water Technologies company.
d. Zurn Industries, LLC.

2. Standard: ASSE 1015.
3. Body Material: Lead free bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 (DN 65) and larger.
4. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.

C. Automatic (Ball Drip) Drain Valves:

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

a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco Fire & Building Products LP.

2. Standard: UL 1726.

3. Pressure Rating: 175 psig minimum.
4. Type: Automatic draining, ball check.

2.5 SPRINKLER SPECIALTY PIPE FITTINGS

A. Flexible, Sprinkler Hose Fittings:

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

   a. Tyco Fire & Building Products LP.
   b. Victaulic Company.
   c. Viking Corporation.

2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 175 psig minimum.
5. Size: Same as connected piping, for sprinkler.

B. Fire-rated pipe penetration assembly:

1. Listed for the application.
2. Include Schedule 40 steel sleeve that protrudes 2” from surface of wall or floor.
3. Seal between pipe and sleeve.
4. Seal between sleeve and wall or floor.

2.6 SPRINKLERS

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

1. Reliable Automatic Sprinkler Co., Inc. (The).
2. Tyco Fire & Building Products LP.
3. Victaulic Company.
4. Viking Corporation.

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Residential Sprinklers: 175 psig maximum.
3. Pressure Rating for Automatic Sprinklers: 175 psig minimum.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Residential Applications: UL 1626.

4. Characteristics: Quick response, standard coverage, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Open Sprinklers with Heat-Responsive Element Removed: UL 199.

E. Sprinkler Finishes:

1. Chrome plated.
2. Bronze.
3. Painted.

F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

G. Sprinkler Guards: Wire cage with fastening device for attaching to sprinkler.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 22 11 16 "Supply Piping for Plumbing."

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

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

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

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

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

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

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

H. Fill wet-type sprinkler system piping with water.

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

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

3.4 JOINT CONSTRUCTION

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

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

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

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

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

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

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

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

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

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

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

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

L. Do not use cleated flanges or glands that use setscrews or wedges that mechanically deform the outer diameter of the pipe.

3.5 VALVE AND SPECIALTIES INSTALLATION

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

1. Route main drain to exterior. Route auxiliary drains to floor drains or exterior.
2. Install drain valves less than 7’-0” AFF.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.

3.6 IDENTIFICATION

A. Paint interior piping where exposed in finished rooms. Paint pipe to match the room background color as viewed from the center of the room. Apply paint per requirements listed in Division 9.

B. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

1. Install pipe identification labels and pipe direction-of-flow labels no farther than 26’-0” apart.

C. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26.

D. Install tags with unique identifier numbers on the following components:

1. Piping flexible connections.
2. Valves.
3. Components not listed above but may potentially require servicing.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire-department equipment.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report test results promptly and in writing to AHJ.

3.8 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.9 DEMONSTRATION

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

B. Engage a factory-authorized service representative to train COR's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 1 Section “Closeout Procedures”.

3.10 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Copper-tube, extruded-tee connections may be used for tee branches in copper tubing instead of specified copper fittings. Branch-connection joints must be brazed.

3.11 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Finished spaces: Concealed or recessed pendent sprinklers, factory painted white, with escutcheons.
2. Unfinished spaces: Rough bronze.
3. Wall Mounting: Sidewall sprinklers.

B. Use sprinklers with temperature ratings higher than expected ambient temperatures. In areas with skylights, use sprinklers with 175 F minimum temperature rating.

C. Use sprinklers with identical temperature ratings throughout compartments.

D. Use sprinklers with identical thermal sensitivities throughout compartments.

E. Use sprinklers with standard response intermediate temperature classification throughout server rooms.

END OF SECTION 21 90 00

SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

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 ACCURACY OF DATA AND CONTRACT DRAWINGS

A. The design drawings are diagrammatic, and they may not show all physical arrangements, offsets, bends, or elbows which may be required for installation of various materials, equipment, piping, and ductwork systems in allotted spaces. The Contractor shall examine these and other available drawings to determine space limitations and interferences. The Contractor shall be responsible for making any minor changes in location of equipment, pipe and ductwork from that shown on drawings and for all physical details required for installation. Cost for adapting Contractor's work to jobsite conditions shall not be considered as basis of an extra cost to contract. The Contractor shall get approval before proceeding with any change.

B. Elevation of piping, ductwork and equipment indicated on drawings are to be used as guidelines to assist Contractor with installations. Minor changes to these elevations may be necessary to eliminate unforeseen interferences.

C. The Contractor must carefully examine the drawings, specifications and project site, and verify all measurements, distances, levels, materials, equipment, etc. before starting work.

D. Drawings shall not be scaled for determining exact dimensions or location of equipment.

E. Except as otherwise specified herein or indicated on drawings, furnish and install all piping, tubing, valves, specialties and supports to connect fixtures and equipment into their respective systems as required for or incidental to the proper operation of the indicated systems. This shall include the following systems:

1. All miscellaneous piping called for on piping and instrument diagrams, regardless of whether or not indicated in the specifications or on the drawings. Reference shall be made to piping and instrument diagrams, control air piping drawings, and manufacturer's equipment drawings to determine full extent or required piping.

1.3 SUMMARY

A. This Section includes the following:

1. Joining materials
2. Dielectric fittings
3. Escutcheons
4. Sleeves
5. Sealants

6. Through-penetration firestop assembly
7. Wall and floor penetrations

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, 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, inside wall spaces, and in chases.

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

F. PVC: Polyvinyl chloride plastic.

G. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.

B. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Electrical Characteristics for Plumbing 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.

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. The Contractor or the Contractor's authorized representative must be present to accept delivery of all equipment and materials furnished by him. The Owner's personnel will not knowingly accept, unload or store anything delivered to the site for the Contractor's use. Inadvertent acceptance of delivered items by a representative of the Owner shall not constitute acceptance or responsibility for any of the materials or equipment. It shall be the Contractor's responsibility to assume all liability for any equipment or materials furnished by him which are delivered to the job site.

D. Storage of materials on the grounds and within the building shall be in strict accordance with instructions of the Owner. Storage of materials within building shall at no time exceed design carrying capacity of the structural system.

E. The Owner assumes no responsibility for materials stored in building or on the site. Each Contractor shall assume full responsibility for all losses or damage due to the storing of his materials.

F. Handle items carefully to avoid damage to components, enclosures and finishes. Follow the manufacturer's rigging instructions when handling and moving equipment.

1.8 COORDINATION

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

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

1.9 CODES AND REGULATIONS

A. All codes and regulations of state and local authorities shall become part of this specification and must be adhered to where they exceed requirements as shown on the drawings or stated in the specifications, without additional cost to the Contract.

1.10 CONTINUITY OF EXISTING SERVICES

A. Do not interrupt or change existing services without prior written approval. When interruption is required, coordinate length of service time with the Owner to minimize disruption of occupant activities.

1.11 OPERATING AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall provide operating and maintenance instruction manuals covering each and every item of equipment and devices furnished or erected by the Contractor prior to "Substantial Completion" as required by Division 1.

B. Each separate manual shall consist of the following:

1. Neatly typewritten table of contents including contractor's name, address and telephone number; list of each product referenced in manual; and name, address

and telephone number of installing contractor and maintenance contractor for each product.

2. Tabbed sections of catalog data and literature for each product including model number, description and component parts; operating procedures; maintenance procedures; servicing and lubrication schedules; description of sequence of operations; parts lists; illustrations, assembly drawings and diagrams required for maintenance; any additional drawings, diagrams, charts or written text which may be required to supplement product data for particular installation; certified test and balance report; list of control point labels, and wiring diagrams.
3. Copy of warranty, bond and/or service contract issued for each product including an information sheet for operations personnel with proper procedures in event of a product failure and instances which might affect validity of warranties or bonds.
4. All literature pertaining to backflow prevention devices shall be in one tabbed section.
5. Full size sheets, if required, shall be folded into special holding pockets. Faxed, handwritten, or illegible materials are not acceptable.
6. Simplified Component Locator document which includes the following:

    a. Cross reference of unique identifier numbers to component descriptions (see “Labeling and Identification” section below for list of required components) arranged in numerical order.
    b. Scale drawing showing location of each component within 2’ of actual location, including elevation above floor.

C. Prior to final inspection or acceptance, fully instruct designated facility operating and maintenance personnel on operation, adjustment and maintenance of products, equipment and systems. Review contents of operating and maintenance manual with personnel in full detail to explain all aspects of operations and maintenance.

1.12 PROTECTION OF ROOF

A. Contractors are cautioned that they must exercise extreme care in any activity involving contact with any installed roof membrane.

B. Construct protective plywood (3/4 in. thick) runways across the roof for moving, setting, and installing equipment and piping systems. No activity on the roof will be permitted without this protection. Start runways at the point of origin of any equipment placed on roof and terminate at the point of installation on curb or base. At completion of work, or when directed by the Owner, completely remove, neatly and cleanly, without damage to roofing system, these protective items and runways.

C. Any and all repairs necessary to bring the roofing system to its original condition shall be made by an approved Roofing Contractor and paid for by the Contractor responsible for the damage

1.13 WORK COORDINATION

A. All Trades shall work in cooperation with each other, and fit their work into the structure as job conditions may demand. All final decisions as to right-of-way and run of pipes and ducts, etc. shall be made by the owner. In general, priority shall be arranged as follows: (in order of preference)

1. Recessed lighting fixtures
2. Piping which must be drainable, including fire protection piping.
3. Sheet metal ductwork
4. Lighting fixtures
5. Plumbing drain lines, downspouts, vents and sprinkler piping
6. Gravity water lines
7. Heating hot and chilled water or steam lines
8. Refrigerant lines
9. Plumbing water supply and gas and air lines
10. Electrical conduit
11. Control air lines or wiring conduit

1.14 INSPECTION

A. The Contractor shall verify the location of underground service, utilities, structures, etc., which may be encountered or be affected by his work and shall be responsible for any damage caused by neglect to provide proper precautions or protection.

B. Any work that is to be concealed, such as inside walls, inside chases, above ceilings, and inside soffits, shall be inspected by Owner or Architect/Engineer prior to concealment.

PART 2 - PRODUCTS

2.1 JOINING MATERIALS

A. 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.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

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

C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

D. Solvent Cements and Primers for Joining PVC Plastic Piping:

1. Primer: ASTM F 656
2. Cement: ASTM D 2564.
3. Use primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

4. Use cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.2 DIELECTRIC FITTINGS

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

B. Dielectric Unions:

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

   a. Jomar
   b. Watts
   c. Zurn/Wilkins

2. Description:

   a. Pressure Rating: 150 psig (1035 kPa) at 180 deg F (82 deg C).
   b. First End Connection: Solder-joint copper alloy.
   c. Second End Connection: Threaded ferrous.

C. Dielectric Flanges:

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

   a. Capitol Manufacturing
   b. Central Plastics
   c. Watts

2. Description:

   a. Factory-fabricated, bolted, companion-flange assembly.
   b. Pressure Rating: 150 psig at 180 deg F.
   c. First End Connection: Solder-joint copper alloy.
   d. Second End Connection: Threaded ferrous.

2.3 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe (or pipe insulation, if used) and an OD that completely covers opening. Use one piece, stamped, chrome-plated steel escutcheons with spring clips.

2.4 SLEEVES

A. PVC Pipe: ASTM D 1785, Schedule 40.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron Pipe: ASTM A 888 or CISPI 301.

D. Ductile Iron Pipe: AWWA/ANSI C150/A21.50

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.5 FOUNDATION WALL SLEEVES

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

1. Advance Products & Systems, Inc.
2. Calpico
3. Linkseal

B. Typical product: Linkseal Model CS

C. Description:

1. Wall Pipe: with integral waterstop on outer dimension. Sized for use with mechanical sleeve seal.
2. Description: Cast iron, ductile iron, or plastic sleeve with integral waterstop on outer dimension. Sized for use with mechanical sleeve seal.

2.6 MECHANICAL SLEEVE SEALS

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

1. Advance Products & Systems, Inc.
2. Calpico
3. Metraflex
4. Linkseal

B. Typical product: Link-Seal Model S-316.

C. Description:

1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material, pipe outer diameter, and sleeve inner diameter, and pipe offset from sleeve hole centerline.
2. Pressure Plates: Stainless steel or composite plastic. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 CASING END SEALS

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

1. Advance Products & Systems, Inc.
2. Calpico
3. Pipeline Seal and Insulator

B. Typical product: Calpico Model W

C. Description:

1. General: Flexible membrane system intended to prevent soil from entering annular space between pipes and casings.
2. Membrane: Either of the following:

a. 1/8" thick flexible coal-tar sheet reinforced with fiberglass.
b. 1/8" neoprene.
c. 1/8" Buna-N (nitrile)
d. 1/8" EPDM

3. Clamps: Stainless band clamps.
4. On split type membranes: Provide adhesive membrane lap seal per manufacturer's installation instructions.

2.8 SEALANTS

A. Reference Division 7 specification for sealant requirements

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

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

C. Install piping in concealed locations. Exceptions:

1. Where otherwise indicated on drawings.
2. Equipment rooms.
3. Service areas.
4. Horizontal piping close to ceiling where no ceiling exists.

D. Where piping is installed exposed, install as follows:

1. Install piping at right angles and parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
2. Install vertical piping close to walls.
3. Install horizontal piping close to ceilings.

E. Where piping is installed above accessible ceilings, install piping 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 where required..

K. Full lengths of pipe shall be used. Short lengths and couplings will not be permitted.

L. Where more than one pipe material specification or valve is allowed for particular service, the Contractor is required to use one and only one of the pipe materials specified throughout project. Two or more different piping materials or valves for same service will not be allowed unless indicated otherwise on drawings or specified herein.

M. Independently support piping so that its weight shall not be supported by the equipment to which it is connected.

N. Size reduction shall be made using reducing fittings; bushings are not acceptable.

O. Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.

P. Cover ends of piping during installation to keep inside of piping clean.

Q. Piping shall not be routed through electrical rooms or transformer vaults, or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

R. Use only wrenches having square flat jaws, or non-metallic strap wrenches on brass specialties; wrench marks not permitted.

S. Select system components with pressure rating equal to or greater than system operating pressure.

T. Install escutcheons at exposed piping penetrations of walls, ceilings, and floors in finished spaces.

U. Fire-Barrier Pipe Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with approved through-penetration firestop assemblies. Refer to Division 07 Section "Penetration and Joint Firestopping " for materials.

V. Aboveground Non-Fire Barrier Pipe Penetrations

1. All except waterproof floors:

a. Install sleeves for pipes passing through concrete walls, masonry walls, gypsum-board partitions, concrete floors, and roof slabs.

Exception: Sleeves are not required for core-drilled holes in concrete.

Exception: Permanent sleeves are not required for holes formed in concrete by removable sleeves.

1) Install sleeves flush with both surfaces.

Exception: In mechanical rooms, install floor sleeves 2 inches above finished floor.

2) Aboveground: Use sleeves that are large enough to provide at least ¼ inch annular clear space between sleeve and pipe or pipe insulation. Use cast iron, galvanized steel, or PVC sleeves on pipe sizes 4 inches and smaller. Use galvanized sheet steel sleeves on pipe sizes larger than 4 inches.
3) Aboveground: Seal annular space around outside of sleeves with grout or sealant.
4) Aboveground: Seal annular space between pipe (or pipe insulation) and sleeve with flexible sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.

2. Waterproof floors:

a. Install sleeves for pipes passing through floors.

1) Install sleeves flush with bottom surface and 2 inches above finished floor.
2) Use sleeves that are large enough to provide at least ¼ inch annular clear space between sleeve and pipe or pipe insulation. Use cast iron, galvanized steel, or PVC sleeves.
3) Seal annular space around outside of sleeves with sealant.
4) Seal annular space between pipe (or pipe insulation) and sleeve with flexible sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.

W. Underground Pipe Penetrations and Transitions

1. Through foundation walls, both sides underground:

a. Install sleeves for pipes passing through foundation walls.

Exception: Sleeves are not required for core-drilled holes in concrete.

Exception: Permanent sleeves are not required for holes formed in concrete by removable sleeves.

1) Install sleeves flush with both surfaces.
2) Use sleeves that are large enough to provide at least 1 inch annular clear space between sleeve and pipe (or pipe insulation). Use cast iron sleeves.

2. Through foundation walls, one side underground:

a. Install foundation wall sleeves for pipes passing through foundation walls.

Exception: Sleeves are not required for core-drilled holes in concrete.

Exception: Permanent sleeves are not required for holes formed in concrete by removable sleeves.

1) Install sleeves flush with both surfaces.
2) Install pipe centered in opening.
3) Install mechanical sleeve seal.

X. Verify final equipment locations for roughing-in.

Y. 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 22 Sections specifying piping systems.

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

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

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

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672.
3. PVC DWV Piping: Join according to ASTM D 2855.

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. Install dielectric unions and flanges 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 plumbing 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. In exposed areas, paint plumbing systems, equipment, and components as specified in Division 09 painting Sections.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. 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 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

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

3.8 GROUTING

A. Mix and install grout for plumbing 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 22 05 00

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SECTION 22 05 19
METERS AND GAGES FOR PLUMBING

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. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages.
4. Gage attachments.

B. Related Sections:

1. Section 21 90 00 "Water Based Fire Suppression System"
2. Section 22 11 16 "Supply Piping for Plumbing" for water meters inside the building.

1.3 SUBMITTALS

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

B. Product Certificates: For each type of meter and gage, from manufacturer.

C. Operation and Maintenance Data: For each type of product indicated, to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Industrial-Style, Liquid-in-Glass Thermometers:

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

   a. Trerice, H. O. Co.
   b. Weiss Instruments, Inc.
   c. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum ; 9-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.
8. Stem: Aluminum, and of length to suit installation.

    a. 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.
11. Scale Range: 30 deg F 240 deg F

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Type: Stepped shank unless straight or tapered shank is indicated.
4. Bore: Diameter required to match thermometer bulb or stem.
5. Insertion Length: Length required to match thermometer bulb or stem.
6. Lagging Extension: Include on thermowells for insulated piping and tubing.
7. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

2.3 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:

    a. Trerice, H. O. Co.
    b. Weiss Instruments, Inc.
    c. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed 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.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
12. Scale Range: 0 psi 200 psi.

2.4 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe 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 direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gage for fluids.

H. Install test plugs in piping tees.

I. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.

J. Install pressure gages in the following locations:

1. Suction and discharge of each domestic water 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.

3.3 ADJUSTING

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

END OF SECTION 22 05 19

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SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING

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. Bronze ball valves.
2. Iron, single-flange butterfly valves
3. Bronze swing check valves.
4. Balancing valves
5. Iron swing check valves

B. Related Sections:

1. Section 22 05 53 "Identification for Plumbing" for valve tags and schedules.

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.

1.4 SUBMITTALS

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

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. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

1. Handwheel: For valves other than quarter-turn types.
2. Handlever: For quarter-turn valves NPS 6 and smaller.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. 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. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.
4. Pressure Seal Joint: with press end adapters as recommended by press end fitting manufacturer.

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

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves:

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

   a. Conbraco Industries, Inc.; Apollo Valves
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Watts; a Watts Water Technologies company.

2. Description:

   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Lead-Free Bronze.
   f. Seats: PTFE or TFE.
   g. Stem: Stainless steel.
   h. Ball: Bronze, vented.
   i. Port: Full.

2.3 IRON BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:

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

   a. Conbraco Industries, Inc.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Watts; a Watts Water Technologies company.

2. Description:

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

2.4 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves:

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

a. Conbraco Industries, Inc.; Apollo Valves
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Watts; a Watts Water Technologies company.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: Lead free bronze.
e. Disc: PTFE or TFE.

2.5 IRON SWING CHECK VALVES

A. Iron Swing Check Valves:

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

a. A.R.I. Flow Control Accessories.
b. Flow-matic Water and Wastewater Valves
c. Val-Matic Valve & Mfg. Corp.

2. Description:

a. Standard: AWWA C508.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze or Stainless Steel.
g. Seat Ring: Bronze or Stainless Steel.

h. Disc Holder: Bronze or Stainless Steel.
i. Disc: Buna-N.
j. Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install check valves for proper direction of flow and as follows:
1. Swing Check Valves: In horizontal position with hinge pin level.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball or butterfly valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service: Ball, or butterfly valves.
4. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze swing check.
b. NPS 2-1/2 and Larger for Domestic Water: Bronze swing check valves.
c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing 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. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

3.5 COMPRESSED-AIR VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with bronze trim.
3. Bronze Swing Check Valves.

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

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron, Single-Flange Butterfly Valves
3. Iron Swing Check Valves

3.6 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless steel trim.
3. Bronze Swing Check Valves.

3.7 DRAIN AND VENT VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless steel trim.
3. Bronze Swing Check Valves.

4. Bronze Gate Valves.

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

1. Iron Valves: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves
3. Iron Gate Valves.

END OF SECTION 22 05 23

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SECTION 22 05 29
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.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Fastener systems.
4. Pipe positioning systems.
5. Equipment supports.

B. Related Sections:

1. Section 22 05 00 “Common Work Results for Plumbing.”

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.

1.5 ACTION SUBMITTALS

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

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: 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 stainless steel.

2.2 THERMAL-HANGER SHIELD INSERTS

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

1. ERICO International Corporation.
2. Rilco Manufacturing Co., Inc.
3. Value Engineered Products, Inc.

B. Insulation-Insert Material: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength. Provide with vapor barrier for piping operating below ambient air temperature.

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

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

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

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 POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

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

C. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

E. 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.

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 Protective shields that 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.

3. 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.

4. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 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.

3.3 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.

3.4 HANGER AND SUPPORT SCHEDULE

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

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

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

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

E. Use galvanized pipe hangers and supports and attachments for Bus Wash service applications.

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

G. Use thermal-hanger shield inserts for insulated piping and tubing.

H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, hangers and supports shall be MSS Type 1 – 46.:

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, vertical piping clamps shall be MSS Type 8 or 42.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, hanger rod attachments shall be MSS Type 13 – 17.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, building attachments shall be MSS Type 18 – 58.

L. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

M. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 05 29

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SECTION 22 05 53
IDENTIFICATION FOR PLUMBING

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. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.3 ACTION SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Labels for Equipment:

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

    a. Brady Corporation.
    b. Marking Services, Inc.
    c. Seton Identification Products.

2. Material and Thickness: Multilayer plastic, 1/8 inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: White.

5. Maximum Temperature: Able to withstand temperatures up to 160 deg F
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

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

1. Brady Corporation.
2. Marking Services Inc.
3. Seton Identification Products.

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

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

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Lettering Size: Size letters according to ASME A13.1 for piping.

2.3 VALVE TAGS

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

1. Brady Corporation.
2. Marking Services Inc.
3. Seton Identification Products.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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.

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Compressed Air Piping:

a. Background: Safety blue.
b. Letter Colors: White.

2. Domestic Water Piping

a. Background: Safety green.
b. Letter Colors: White.

3. Sanitary Waste and Storm Drainage Piping:

a. Background Color: Safety white.
b. Letter Color: Black.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Cold Water: 1-1/2 inches, round.
b. Hot Water: 1-1/2 inches, round.
c. Compressed Air: 1-1/2 inches, round.

END OF SECTION 22 05 53

SECTION 22 07 00
INSULATION FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes:

1. Insulation Materials
2. Insulating Cements
3. Adhesives
4. Mastics
5. Sealants
6. Factory Applied Jackets
7. Field Applied Jackets
8. Tapes
9. Protective Shielding Guards

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. 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.
6. Detail application at linkages of control devices.
7. Detail field application for each equipment type.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. 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.

B. 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 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29 "Hangers and Supports for Plumbing."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 Scheduling articles for where insulating materials shall be applied.

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

C. Mineral-Fiber, Preformed Pipe Insulation:

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

   a. Johns Manville; a Berkshire Hathaway company.
   b. Knauf Insulation.
   c. Owens Corning.

2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

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

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

   a. Ramco Insulation, Inc.

2.3 ADHESIVES

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

B. For indoor applications, adhesives shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.

D. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

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

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Knauf Insulation
    d. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

2.5 SEALANTS

A. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Joint Sealants:

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. Pittsburgh Corning Corporation.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

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

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.

c. Foster Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

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

a. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. Proto Corporation.
d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

a. Avery Dennison Corporation, Specialty Tapes Division.
b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
e. Venture Tape.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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

    a. Avery Dennison Corporation, Specialty Tapes Division.
    b. Compac Corporation.
    c. Ideal Tape Co., Inc., an American Biltrite Company.
    d. Venture Tape.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.9 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

    a. McGuire Manufacturing.
    b. Plumberex Specialty Products, Inc.
    c. Truebro.
    d. Zurn Industries, LLC.

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.

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-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge.

    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 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.
5. Manholes.
6. Handholes.

3.4 PENETRATIONS

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

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

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

C. 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 7 "Penetration and Joint Firestopping" for firestopping and fire-resistive joint sealers.

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, 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 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 MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. 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 mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

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

3.8 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 "Exterior Painting" and "Interior Painting."

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

    a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, two locations of threaded strainers, three locations of threaded valves, and for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Hydropneumatic and expansion tank insulation shall be one of the following:

1. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. Insulation shall be one of the following:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/2 and Smaller: Insulation shall be one of the following:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 2 and Larger: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.

C. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be the following:

    a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be one of the following:

    a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation shall be the following:

    a. Protective shielding pipe covers.

F. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:

    a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping and Equipment, Concealed:

1. None.

D. Piping, Exposed:

1. None outside the bus wash environment.
2. PVC: 30 mils thick in bus wash environment.

E. Equipment, Exposed:

1. None outside the bus wash environment.
2. PVC: 30 mils (0.8 mm) thick in bus wash environment.

END OF SECTION 22 07 00

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SECTION 22 11 16
SUPPLY PIPING FOR PLUMBING

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. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
2. Encasement for piping.

B. Related Requirements:

1. Section 22 05 00 “Common Work Results for Plumbing.”
2. Section 22 05 19 "Meters and Gages for Plumbing."
3. Section 22 05 29 “Hangers and Supports for Plumbing;”
4. Section 22 05 53 "Identification for Plumbing."
5. Section 22 11 19 “Supply Piping Specialties for Plumbing.”

1.3 SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

G. Copper Pressure-Seal-Joint Fittings:

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

    a. Elkhart Products Corporation.
    b. NIBCO INC.
    c. Viega LLC.

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

H. Copper-Tube, Extruded-Tee Connections:

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

    a. T-DRILL Industries Inc.

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

2.3 STAINLESS-STEEL PIPING

A. Potable-water piping and components shall comply with NSF 61 Annex G.

B. Stainless-Steel Pipe: ASTM A 312/A 312M, Schedule 40.

C. Stainless-Steel Pipe Fittings: ASTM A 815/A 815M.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

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

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

2.5 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105/A21.5.

B. Form: Sheet.

C. Color: Black.

2.6 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

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

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

3.2 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 shutoff valve immediately upstream of each dielectric fitting.

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 to permit valve servicing.

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

H. Install piping free of sags and bends.

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

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

K. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 22 05 19 "Meters and Gages for Plumbing."

L. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 11 23 "Supply Piping Pumps for Plumbing."

M. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 05 19 "Meters and Gages for Plumbing."

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 00 "Common Work Results for Plumbing."

O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 00 “Common Work Results for Plumbing.”

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 00 “Common Work Results for Plumbing."

3.3 JOINT CONSTRUCTION

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

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

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

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

D. Soldered Joints for Copper Tubing: 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."

E. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

F. 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.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for 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.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 22 05 29 "Hangers and Supports for Plumbing."

3.7 CONNECTIONS

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

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

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

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 53 "Identification for Plumbing."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
b. 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:

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 authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

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

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

b. 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.
c. 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.
d. 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 it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

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

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

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

    a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow 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.

3.11 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. Repeat procedures if biological examination shows contamination.
e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping according to the requirements for potable domestic water piping.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

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

3.12 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. Aboveground domestic water piping, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Stainless steel Schedule 40 pipe, welded fittings, and welded joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves for piping NPS 2-1/2 and larger.
2. 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 22 11 16

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SECTION 22 11 19
SUPPLY PIPING SPECIALTIES FOR PLUMBING

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. Vacuum breakers.
2. Backflow preventers.
3. Temperature-actuated, water mixing valves.
4. Strainers.
5. Hose bibs.
6. Wall hydrants.
7. Water-hammer arresters.
8. Trap-seal primer device.

B. Related Requirements:

1. Section 22 05 19 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14. Mark "NSF-pw" on plastic piping components.

2.2 PERFORMANCE REQUIREMENTS

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

2.3 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:

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

    a. Cash Acme.
    b. Conbraco Industries, Inc.
    c. Prier Products, Inc.
    d. Watts; a Watts Water Technologies company.
    e. Zurn Industries, LLC.

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.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

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

    a. Conbraco Industries, Inc.
    b. Watts; a Watts Water Technologies company.
    c. Zurn Industries, LLC.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron or steel with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight-through flow.
8. Accessories:

    a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.5 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:

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

   a. Lawler Manufacturing Company, Inc.
   b. Leonard Valve Company.
   c. Powers.

2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Valve Finish: Rough bronze.
8. Piping Finish: Copper.
9. Cabinet: Factory fabricated, stainless steel, for surface mounting and with hinged, stainless-steel door.

B. Individual-Fixture, Water Tempering Valves:

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

   a. Lawler Manufacturing Company, Inc.
   b. Leonard Valve Company.
   c. WATTS.

2. Standard: ASSE 1016 or ASSE 1070, 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. Finish: Rough or chrome-plated bronze.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron or steel with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Drain: Pipe plug.

2.7 HOSE BIBBS

A. Hose Bibbs:

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

    a. Chicago Faucets
    b. Prier Products, Inc.
    c. Smith, Jay R. Mfg. Co.
    d. Watts; a Watts Water Technologies company.
    e. Woodford Manufacturing Company.
    f. Zurn Industries, LLC.

2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Finished Rooms: Chrome or nickel plated.
10. Operation for Equipment Rooms: Wheel handle or operating key.
11. Operation for Finished Rooms: Operating key.
12. Include operating key with each operating-key hose bibb.
13. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.8 WALL HYDRANTS

A. Non-freeze Wall Hydrants:

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

    a. Prier Products, Inc.
    b. Smith, Jay R. Mfg. Co.
    c. Watts; a Watts Water Technologies company.
    d. Woodford Manufacturing Company.
    e. Zurn Industries, LLC.

2. Standard: ASSE 1019, Type B.
3. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
4. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Pressure Rating: 125 psig.
6. Operation: Loose key.

7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
8. Inlet: NPS 1/2 or NPS 3/4.
9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.9 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

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

   a. Precision Plumbing Products.
   b. Sioux Chief Manufacturing Company, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Watts; a Watts Water Technologies company.
   e. Zurn Industries, LLC.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.10 TRAP-SEAL PRIMER DEVICE

A. Drainage-Type, Trap-Seal Barrier Device:

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

   a. Sioux Chief Manufacturing Company, Inc.
   b. Smith, Jay R. Mfg. Co.
   c. Watts; a Watts Water Technologies company.
   d. Zurn Industries, LLC.

2. Standard: ASSE 1072.
3. Size: NPS 1-1/2 minimum.
4. Material: Chemical Resistant Rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

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

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-drain. Locate air-gap device

attached to or under backflow preventer. Simple air breaks are unacceptable for this application.

3. Do not install bypass piping around backflow preventers.

B. Install water-control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

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

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

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

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

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

G. Install trap-seal barrier device in the drain outlet for all floor drains, trench drains, and hub drains.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

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. Reduced-pressure-principle backflow preventers.
2. Calibrated balancing valves.
3. Individual fixture water tempering valves.
4. Hose stations.

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 22 05 53 "Identification for Plumbing."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

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

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

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 22 11 19

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SECTION 22 11 23
SUPPLY PIPING PUMPS FOR PLUMBING

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. In-line, sealless centrifugal pumps.

1.3 DEFINITIONS

A. 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.

B. ECM Motor: Electronically Commutated Motor/Permanent Magnet Motor

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

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

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.8 COORDINATION

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

PART 2 - PRODUCTS

2.1 IN-LINE, WET ROTOR PUMPS

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

1. Bell & Gossett; a Xylem brand.
2. Grundfos Pumps Corp.
3. TACO Incorporated.

B. Description: Factory-assembled and -tested, single-stage, in-line, wet rotor domestic hot water circulating pumps.

C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
2. Casing: Bronze, with threaded or companion-flange connections.
3. Impeller: Corrosion-resistant material.
4. Motor: Single speed, unless otherwise indicated. Motor shall be non-overloading with built-in thermal protection and built-in impedance protection.

2.2 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Settings: Start pump at 115 deg F and stop pump at 120 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install pumps with motors and pump shafts horizontal.

E. Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing."

F. Install thermostats in hot-water return piping.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16 "Supply Piping for Plumbing." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.

1. Install shutoff valve and strainer on suction side of each in-line, sealless centrifugal pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping.
2. Install shutoff valves on piping connections to booster-pump suction and discharge headers. Install ball or butterfly valves same size as suction and discharge headers.
3. Install union, flanged, or grooved-joint connections to booster pump suction and discharge headers.
4. Install valved bypass, same size as and between piping, at connections to booster pump suction and discharge headers.
5. Install flexible connectors, same size as connected piping, on connections to booster pump suction and discharge headers.

D. Connect thermostats, to pumps that they control.

E. Connect water piping to hydropneumatic tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.

1. Valves NPS 2 and Smaller: Gate or ball.
2. Valves NPS 2-1/2 (DN 65) and Larger: Gate or butterfly.
3. Drain Valves: NPS 3/4 (DN 20) gate or ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.

3.4 IDENTIFICATION

A. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing."

3.5 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. Tests and Inspections:

1. Perform visual and mechanical inspection.
2. Verify that air precharge in precharged tanks is correct.
3. Test operation of tank accessories and devices.
4. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
5. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Pumps and controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service on in-line, sealless centrifugal pumps.

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. Set thermostats for automatic starting and stopping operation of pumps.
5. 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.

6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.7 ADJUSTING

A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

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

END OF SECTION 22 11 23

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SECTION 22 13 16
DRAIN AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Encasement for underground metal piping.

B. Related Sections:

1. Section 22 13 29 "Drain Pumps" for effluent and sewage pumps.

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. Waste, Force-Main Piping: 100 psig.

1.4 SUBMITTALS

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

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

1.6 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

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 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. ANACO-Husky.
    b. Fernco Inc.
    c. Mission Rubber Company, LLC; a division of MCP Industries.
    d. Tyler Pipe; a subsidiary of McWane Inc.
2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. ANACO-Husky.
    b. Clamp-All Corp.
    c. Mission Rubber Company, LLC; a division of MCP Industries.
    d. Tyler Pipe; a subsidiary of McWane Inc.
2. Standards: ASTM C 1277 and ASTM C 1540.

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

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight class. Include square-cut-grooved or threaded ends matching joining method.

B. Steel Pipe Pressure Fittings:

1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Schedule 40, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.

C. Cast-Iron Flanges: ASME B16.1, Class 125.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.5 COPPER TUBE AND FITTINGS

A. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B 88, Type K and Type M (ASTM B 88M, Type A and Type C), water tube, drawn temper.

C. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

D. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

E. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.6 PVC PIPE AND FITTINGS

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

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Solvent Cement: ASTM D 2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Unshielded, Nonpressure Transition Couplings:

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

1) Fernco Inc.
2) Froet Industries LLC.
3) Mission Rubber Company, LLC; a division of MCP Industries.

b. Standard: ASTM C 1173.
c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. Sleeve Materials:

1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.8 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A 674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch minimum thickness.

C. Form: Sheet.

D. Color: Black.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 20 00 "Earth Moving."

3.2 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 elevations.

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: 2 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."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

N. Install steel piping according to applicable plumbing code.

O. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

P. Install aboveground PVC piping according to ASTM D 2665.

Q. Install underground PVC piping according to ASTM D 2321.

R. Install force mains at elevations indicated.

S. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping. Comply with requirements for backwater valves specified in Section 22 13 19 "Drain Piping Specialties for Plumbing."
2. 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 Section 22 13 19 "Drain Piping Specialties for Plumbing."
3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 22 13 19 "Drain Piping Specialties for Plumbing."

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

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 00 "Common Work Results for Plumbing."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 00 "Common Work Results for Plumbing."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 00 "Common Work Results for Plumbing."

3.3 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. 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.

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

1. Apply appropriate tape or thread compound to external pipe threads 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.

D. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

E. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

F. Plastic, Non-pressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Unshielded, non-pressure transition couplings.
3. In Force Main Piping: Fitting-type transition couplings.

B. Dielectric Fittings:

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

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 22 05 23 “General-Duty Valves for Plumbing.”

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install gate or full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Comply with requirements for backwater valve specified in Section 22 13 19 "Drain Piping Specialties for Plumbing."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 05 29 "Hangers and Supports for Plumbing."

3.7 CONNECTIONS

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

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

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Install horizontal backwater valves with cleanout cover flush with floor.
6. Comply with requirements for backwater valves, cleanouts, and drains specified in Section 22 13 19 "Drain Piping Specialties for Plumbing."
7. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:

1. Sewage Pump: To sewage pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. 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.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing."

3.9 FIELD QUALITY CONTROL

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

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

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

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

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

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air

pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 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.

D. Exposed PVCPiping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.11 PIPING SCHEDULE

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

B. Aboveground, soil and waste piping shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

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

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

3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: Unshielded, non-pressure transition couplings.

D. Underground, soil, waste, and vent piping shall be any of the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

E. Sanitary-sewage force mains shall be any of the following:

1. Hard copper tube, Type K (Type A); copper pressure fittings; and soldered joints.
2. Galvanized-steel pipe, pressure fittings, and threaded joints.

    a. Sanitary-sewage force main routed in bus wash area shall be galvanized-steel pipe.

END OF SECTION 22 13 16

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SECTION 22 13 19
DRAIN PIPING SPECIALTIES FOR PLUMBING

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. Roof drains.
2. Cleanouts.
3. Floor drains.
4. Miscellaneous sanitary drainage piping specialties.
5. Flashing materials.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

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

1.7 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 ROOF DRAINS

A. Refer to Schedules on drawings for complete description of Roof Drains.

B. Cast-Iron, Large-Sump, General-Purpose Roof Drains:

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

    a. Jay R. Smith Mfg. Co.
    b. Josam Company.
    c. Wade; a subsidiary of McWane Inc.
    d. Watts; a Watts Water Technologies company.
    e. Zurn Industries, LLC.

2. Standard: ASME A112.6.4.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 14-to 16-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Outlet: Bottom.
7. Outlet Type: No hub.
8. Extension Collars: Required.
9. Underdeck Clamp: Required.
10. Sump Receiver Plate: Required.
11. Dome Material: Aluminum.
12. Perforated Gravel Guard: Stainless steel.
13. Vandal-Proof Dome: Required.

2.2 BACKWATER VALVES

A. Horizontal, Plastic Backwater Valves:

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

    a. Sioux Chief Manufacturing Company, Inc.
    b. Spears Manufacturing Company.
    c. Zurn Industries, LLC.

2. Size: Same as connected piping.
3. Body: PVC.

2.3 CLEANOUTS

A. Metal Floor Cleanouts:

1. ASME A112.36.2M, Cast-Iron Cleanouts:

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

1) Smith, Jay R. Mfg. Co.
2) Watts; a Watts Water Technologies company.
3) Zurn Industries, LLC.

2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron.
5. Closure: Brass plug with tapered threads.
6. Adjustable Housing Material: Cast iron .
7. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
8. Top Loading Classification: Medium Duty.

B. Cast-Iron Wall Cleanouts:

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

a. Smith, Jay R. Mfg. Co.
b. Watts; a Watts Water Technologies company.
c. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Cast-iron soil pipe test tee as required to match connected piping.
5. Closure: drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

2.4 FLOOR DRAINS

A. Floor Drains:

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

a. Smith, Jay R. Mfg. Co.
b. Watts; a Watts Water Technologies company.
c. Zurn Industries, LLC.

2. Body Material: Cast Iron.

3. Seepage Flange: Required.
4. Clamping Device: Required.
5. Outlet: Bottom.
6. Top or Strainer Material: Nickel bronze.
7. Top Loading Classification: Medium Duty.
8. Trap Material: Same as connected drain pipe.
9. Trap Pattern: Deep-seal P-trap.
10. Trap Features: Trap-seal primer valve drain connection.

B. Hub Drains

1. Description:

a. Field fabricated open drain with P-trap.
b. Material: Same as connected drain pipe.
c. Trap Material: Same as connected drain pipe.
d. Trap Pattern: Deep-seal P-trap.
e. Trap Features: Trap-seal primer valve drain connection.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. 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.

B. Stack Flashing Fittings:

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

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

1. Size same as drainage piping up to NPS 6. UseNPS 6 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.

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

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

F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

    a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

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

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

H. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

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

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

K. Install floor-drain, trap-seal barrier for all floor and trench drains.

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

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

N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

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

3.2 CONNECTIONS

A. Comply with requirements in Section 22 13 16 "Drain and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 PROTECTION

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

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

END OF SECTION 22 13 19

SECTION 22 13 29
DRAIN 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. Submersible pumps for storm and sanitary drain systems.
2. Basins and basin covers.
3. Pump removal systems.
4. Pump controls.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE PUMPS FOR SANITARY DRAIN SYSTEMS:

A. General: Complete assembly including basin, two pumps, pump controller, pump removal guide rail, and associated accessories.

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

1. EBARA Fluid Handling.
2. PACO Pumps; Grundfos Pumps Corporation, USA.
3. Weil Pump Company, Inc.
4. Zoeller Company.

C. Pump:

1. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.

a. Pump type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump. Factory assembled and tested.
b. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
c. Impeller: Capable of passing 2” solids. Statically and dynamically balanced, cast iron, bronze, or stainless steel, non-clog design for solids handling, and keyed and secured to shaft.
d. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
e. Seals: Dual Mechanical.
f. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

D. Controls:

1. Enclosure: NEMA 250, Type 4X; wall-mounted.
2. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4. Hand-Off-Auto Switch: for each pump, accessible without opening control enclosure.
5. High-Water Alarm: Sound audible alarm.
6. Control-Interface: With remote alarm contacts for building automation system.

E. Guide-Rail Supports:

1. Description: Structural support with remote piping disconnect with allows pump to be removed without disturbing piping or control switches.

    a. Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
    b. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
    c. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
    d. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
    e. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
    f. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
    g. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

2.2 SEWAGE-PUMP BASINS AND BASIN COVERS

A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.

1. Material: Fiberglass.
2. Reinforcement: Mounting plates for pumps, fittings and accessories.
3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and filling are specified in Division 31 "Earth Moving."

3.2 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.3 INSTALLATION

A. Wiring Method: Comply with requirements in Division 26 "Low-Voltage Electrical Power Conductors and Cables."

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 13 16 "Drain and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.5 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 motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Pumps and controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.7 DEMONSTRATION

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

END OF SECTION 22 13 29

SECTION 22 15 13
GENERAL-SERVICE COMPRESSED-AIR 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 piping and related specialties for general-service compressed-air systems:

1. Pipes, tubes, and fittings.
2. Joining materials.
3. Valves.
4. Flexible pipe connectors.
5. Specialties.
6. Quick couplings.
7. Hose assemblies.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. HDPE: High-density polyethylene plastic.

E. NBR: Acrylonitrile-butadiene rubber.

F. PE: Polyethylene plastic.

G. PVC: Polyvinyl chloride plastic.

H. High-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures between 150 and 200 psig.

I. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig or less.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. ASME Compliance:

1. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Compressed-Air Service: Do not interrupt compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary compressed-air service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of compressed-air service.
2. Do not proceed with interruption of compressed-air service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Schedule 40, Steel Pipe: ASTM A53/A53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1.

1. Steel Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106, Schedule 40, galvanized seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.
3. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.
4. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded.
5. Wrought-Steel Butt-Welding Fittings: ASME B16.9, Schedule 40.
6. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel.

2.2 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for compressed-air 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.

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

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

D. 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.

2.3 VALVES

A. Metal Ball, Butterfly, Check, and Gate Valves: Comply with requirements in Section 22 05 23, Article 2.2 "Bronze Ball Valves," Article 2.3 "Iron Butterfly Valves," Article 2.4 "Bronze Swing Check Valves," and Article 2.5 "Iron Swing Check Valves."

2.4 FLEXIBLE PIPE CONNECTORS

A. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: 200 psig minimum.
2. End Connections, NPS 2 and Smaller: Threaded steel pipe nipple.
3. End Connections, NPS 2-1/2 and Larger: Flanged steel nipple.

2.5 SPECIALTIES

A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.

1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

B. Air-Line Pressure Regulators: Diaphragm or pilot operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig minimum inlet pressure, unless otherwise indicated.

C. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated.

2.6 QUICK COUPLINGS

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

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

1. Aeroquip Corporation; Eaton Corp.
2. Parker Hannifin Corp.; Fluid Connectors Group; Quick Coupling Div.

3. Schrader-Bridgeport/Standard Thomson.
4. Snap-Tite, Inc.; Quick Disconnect & Valve Division.

C. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.

D. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.

1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
2. Plug End: Straight-through type with barbed outlet for attaching hose.

E. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.

1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
2. Plug End: Straight-through type with barbed outlet for attaching hose.

F. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.

1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
2. Plug End: With barbed outlet for attaching hose.

2.7 HOSE ASSEMBLIES

A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig minimum working pressure, unless otherwise indicated.

1. Hose: Reinforced double-wire-braid, CR-covered hose for compressed-air service.
2. Hose Clamps: Stainless-steel clamps or bands.
3. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
4. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Low-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:

1. NPS 2 and Smaller: Schedule 40, galvanized-steel pipe; threaded, malleable-iron fittings; and threaded joints.
2. NPS 2-1/2 to NPS 4: Schedule 40, galvanized-steel pipe; threaded, malleable-iron fittings; and threaded joints.

3.2 VALVE APPLICATIONS

A. Metal General-Duty Valves: Comply with requirements and use valve types specified in Section 22 05 23, Article 2.2 "Bronze Ball Valves," Article 2.3 "Iron Butterfly Valves," Article 2.3 "Bronze Check Valves," and Article 2.4 "Iron Check Valves," according to the following:

1. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.
2. Equipment Isolation NPS 2 and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

B. General-Duty Valves for Aluminum Piping System: Provide valves, made by piping system manufacturer, that are compatible with piping.

3.3 PIPING INSTALLATION, GENERAL

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

B. Install piping concealed from view and protected from physical contact by building occupants, 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 otherwise indicated.

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

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

F. Install air and drain piping with 1 percent slope downward in direction of flow.

G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.

H. Equipment and Specialty Flanged Connections:

1. Use steel companion flange with gasket for connection to steel pipe.

I. Flanged joints may be used instead of specified joint for any piping or tubing system.

J. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

K. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

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

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 00 "Common Work Results for Plumbing"

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 00 "Common Work Results for Plumbing"

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 00 "Common Work Results for Plumbing"

3.4 JOINT CONSTRUCTION

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

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

C. 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.

D. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.

E. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

F. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.5 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Specification 220523.

B. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.6 DIELECTRIC FITTING INSTALLATION

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

B. NPS 2 and Smaller: Use dielectric unions.

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

3.7 FLEXIBLE PIPE CONNECTOR INSTALLATION

A. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.8 SPECIALTY INSTALLATION

A. Install air-main pressure regulators in compressed-air piping at or near air compressors.

B. Install quick couplings at piping terminals for hose connections.

3.9 CONNECTIONS

A. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.

B. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment and machine.

3.10 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Vertical Piping: MSS Type 8 or 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet or Less: MSS Type 1, adjustable, steel clevis hangers.
2. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

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

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

3.11 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.12 FIELD QUALITY CONTROL

A. Perform field tests and inspections.

B. Tests and Inspections:

1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop-in pressure.
2. Repair leaks and retest until no leaks exist.

C. Prepare test reports.

END OF SECTION 22 15 13

SECTION 22 31 00
DOMESTIC WATER SOFTENERS

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. Water anti-scaler.

1.3 ACTION SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water softeners.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

1. Signed by manufacturer certifying that water softener complies with requirements.
2. Mineral tank pressure test report. Provide report of pressure tests. Report shall identify each tank by serial number, shall indicate the maximum pressure attained, and shall be signed by the individual that conducted the test.

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.

B. Maintenance service agreement.

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.

1.7 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water softeners and are based on the specific system indicated.

B. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

1.8 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.

1.9 WARRANTY

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

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

   a. Structural failures of mineral and brine tanks.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   d. Attrition loss of resin exceeding 3 percent per year.
   e. Mineral washed out of system during service.
   f. Effluent turbidity greater and color darker than incoming water.
   g. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.

2. Warranty Period: 5 years from date of Substantial Completion.

1.10 MAINTENANCE SERVICE

A. Maintenance: Submit four copies of manufacturer's "Agreement for Continued Service and Maintenance," before Substantial Completion, for Owner's acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing to include replacing materials and equipment. Include one-year term of agreement with option for one-year renewal.

PART 2 - PRODUCTS

2.1 WATER ANTI-SCALER

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

1. Eco Water Systems.
2. Pelican.

3. WATTS.

B. Description: Factory-assembled, pressure-type water softener.

1. Standard: Comply with NSF 61 Annex, "Drinking Water System Components - Health Effects."
2. Configuration: Single unit with one mineral tank.
3. Mounting: On Pad.
4. Mineral Tanks: FRP, pressure-vessel quality.

a. Construction: Non-ASME code.
b. Pressure Rating: 125 psig minimum.
c. Support Legs or Skirt: Non-metallic.
d. Upper Distribution System: Single-point, diffuser type.
e. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers, and arranged for even flow distribution through resin bed.
f. Handholes: 4 inches round or 4 by 6 inches elliptical, in top head and lower sidewall of tanks 30 inches and smaller in diameter.
g. Manhole: 11 by 15 inches in top head of tanks larger than 30 inches in diameter.
h. Liner: PE, ABS, or other material suitable for potable water.

5. Flow Control: To control collapse of tank in the event the plumbing system is drained, a vacuum breaker shall be installed on the outlet side of the tank.
6. Factory-Installed Accessories:

a. Piping, valves, tubing, and drains.
b. Sampling cocks.
c. Main-operating-valve position indicators.
d. Water meters.

C. Capacities and Characteristics:

1. Water Analysis:

a. Hardness: 20 grains/gal.

2. Water Consumption: 20 gal./day.

2.2 CHEMICALS

A. Mineral: High-capacity ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.

2.3 WATER-TESTING SETS

A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.4 SOURCE QUALITY CONTROL

A. Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WATER ANTI-SCALE INSTALLATION

A. Equipment Mounting:

1. Install water anti-scaler on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 33.

B. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16 "Supply Piping for Plumbing." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to equipment, allow space for service and maintenance of equipment.

C. Install shutoff valves on raw-water inlet and outlet piping of each mineral tank.

1. Metal and plastic valves are specified in Section 22 05 23 “General-Duty Valves for Plumbing”.
2. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

D. Install valved bypass in water piping around water anti-scaler.

1. Metal and plastic valves are specified in Section 22 05 23 “General-Duty Valves for Plumbing”. Water piping is specified in Section 22 11 16 "Supply Piping for Plumbing."

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing."

3.4 FIELD QUALITY CONTROL

A. 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 unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Water anti-scaler will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

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.

3.6 DEMONSTRATION

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

END OF SECTION 22 31 00

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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, gas-fired, high-efficiency, storage, domestic-water heaters.
2. Domestic-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.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

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

C. 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.

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

1.6 COORDINATION

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

1.7 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:

1) Storage Tank: Five years.
2) Controls and Other Components: Three year(s).

b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:

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

a. Bock Water Heaters.
b. Bradford White Corporation.
c. Heat Transfer Products, Inc.
d. Smith, A. O. Corporation.

2. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
3. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

4. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Electronic anode system or replaceable magnesium anode.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
e. Jacket: Steel with enameled finish.
f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
g. Temperature Control: Adjustable thermostat.
h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

B. Tankless Water Heaters:

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

a. Bradford White Corporation.
b. Heat Transfer Products.
c. Navien, Inc.
d. Smith, A. O. Corporation

2. Standard: ANSI Z21.10.3/CSA 4.3 for gas-fired, instantaneous, domestic-water heaters for indoor application.
3. Construction: Copper piping or tubing complying with NSF 61 Annex G barrier materials for potable water, without storage capacity.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Heat Exchanger: Copper tubing.
d. Insulation: Comply with ASHRAE/IESNA 90.1.
e. Jacket: Metal, with enameled finish, or plastic.
f. Burner: For use with tankless, domestic-water heaters and natural-gas fuel.

4. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
5. Temperature Control: Adjustable thermostat.
6. Support: Bracket for wall mounting.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Hot-Water Storage Tank: Connected with piping to circulating pump and domestic-water heater.

1. Construction: According to ASME Boiler and Pressure Vessel Code: Section VIII, steel with 150-psig (1035-kPa) working-pressure rating.
2. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

    a. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
    b. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

3. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
4. Factory-Installed Storage-Tank Appurtenances:

    a. Anode Rods: Electronic anode system or replaceable magnesium anode.
    b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005, factory installed.
    c. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
    d. Jacket: Steel with enameled finish.
    e. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

B. Thermal Expansion Tanks:

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

    a. AMTROL, Inc.
    b. Smith, A. O. Corporation.
    c. Watts.

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 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
    c. Air-Charging Valve: Factory installed.

C. 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.

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

E. Heat-Trap Fittings: ASHRAE 90.2.

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.

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

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 and storage tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

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

C. 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 3.

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. Tankless, Domestic-Water Heater Mounting: Install tankless, domestic-water heaters on wall bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

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

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 22 05 23 “General-Duty Valves for Plumbing.”

D. Install gas-fired, domestic-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 Section 23 11 23 "Facility Natural-Gas Piping."

E. 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.

F. Install 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.

G. 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 Section 22 05 23 "General Duty Valves for Plumbing."

H. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing."

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

J. Fill domestic-water heaters with water.

K. Charge domestic-water thermal expansion tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 22 11 16 "Supply Piping for Plumbing."

B. Comply with requirements for gas piping specified in Section 23 11 23 "Facility Natural-Gas Piping."

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

D. 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 Section 22 05 53 "Identification for Plumbing."

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. 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 domestic-water heaters.

END OF SECTION 22 34 00

SECTION 22 40 00
PLUMBING FIXTURES

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 conventional plumbing fixtures and related components:

1. Faucets for lavatories and sinks.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Water closets.
7. Lavatories.
8. Service sinks.
9. Service basins.
10. Owner-furnished fixtures.

B. Related Sections include the following:

1. Division 22 Section "Supply Piping Specialties for Plumbing " for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

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

C. FRP: Fiberglass-reinforced plastic.

D. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

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

B. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

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

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

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

1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
2. Faucets: ASME A112.18.1.
3. Hose-Connection Vacuum Breakers: ASSE 1011.
4. Hose-Coupling Threads: ASME B1.20.7.
5. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
6. NSF Potable-Water Materials: NSF 61.
7. Pipe Threads: ASME B1.20.1.
8. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
9. Supply Fittings: ASME A112.18.1.
10. Brass Waste Fittings: ASME A112.18.2.

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

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Manual-Operation Flushometers: ASSE 1037.
4. Plastic Tubular Fittings: ASTM F 409.
5. Brass Waste Fittings: ASME A112.18.2.
6. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

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

1. Flexible Water Connectors: ASME A112.18.6.
2. Floor Drains: ASME A112.6.3.
3. Hose-Coupling Threads: ASME B1.20.7.
4. Off-Floor Fixture Supports: ASME A112.6.1M.
5. Pipe Threads: ASME B1.20.1.
6. Plastic Toilet Seats: ANSI Z124.5.
7. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
2. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
3. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
4. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

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

a. American Standard Companies, Inc.
b. Bradley Corporation.
c. Chicago Faucets.
d. Elkay Manufacturing Co.
e. Just Manufacturing Company.
f. Kohler Co.
g. Moen, Inc.
h. T & S Brass and Bronze Works, Inc.
i. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Single-control mixing valve. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

a. Body Material: Commercial, solid brass.
b. Finish: Polished chrome plate.

c. Maximum Flow Rate: 0.5 gpm.
d. Centers: 4 inches.
e. Mounting: Deck, exposed.
f. Valve Handle(s): N/A.
g. Inlet(s): NPS 1/2 male shank.
h. Spout: Rigid type.
i. Spout Outlet: Laminar flow.
j. Operation: Sensor.
k. Drain: Grid.
l. Tempering Device: Thermostatic.

2.2 SERVICE SINKS

A. Service Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: See fixture schedule on drawings for complete description of fixture and accessories.

a. American Standard Companies, Inc.
b. Kohler Co.
c. Crane Plumbing, L.L.C./Fiat Products.
d. Mustee
e. Fiat
f. Kohler Co.

2. Faucets:

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

1) American Standard.
2) Chicago Faucets.
3) Elkay.
4) Kohler.
5) T & S Brass and Bronze Works.
6) Zurn.

b. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

1) Body Material: Commercial, solid brass.
2) Finish: Polished chrome plate.
3) See Plumbing fixture schedule for fixture description and model numbers.
4) Control: Wrist blade handles.
5) Spout: Swing, shaped tube.
6) Spout Outlet: Non-Aerator Laminar Flow.
7) Per: ASME A112.18.1.

2.3 SERVICE BASINS

A. Service Basins:

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

    a. Acorn Engineering Company.
    b. Crane Plumbing, L.L.C./Fiat Products.
    c. Florestone Products Co., Inc.
    d. Precast Terrazzo Enterprises, Inc.
    e. Stern-Williams Co., Inc.
    f. Mustee, E. L. & Sons, Inc.
    g. Zurn Plumbing Products Group; Light Commercial Operation.

2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard. See fixture schedule on drawings for complete description of fixture and accessories.

    a. Shape: Square.
    b. Size: 24 by 24 inches.
    c. Height: 12 inches with dropped front.
    d. Rim Guard: On all top surfaces.
    e. Color: Not applicable.
    f. Drain: Grid with NPS 3 outlet.

2.4 FLUSHOMETERS

A. Flushometers:

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

    a. Sloan Valve Company.
    b. Zurn Plumbing Products Group; Commercial Brass Operation.
    c. Hydrotek International, Inc.

2. Description: Flushometer for water-closet-type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
3. See fixture schedule on drawings for complete description of fixture and accessories.

    a. Internal Design: Diaphragm operation.
    b. Style: Exposed.
    c. Inlet Size: NPS 3/4.
    d. Trip Mechanism: Hard-wired, electric-sensor actuator.
    e. Consumption: 1.28 gal./flush.
    f. Tailpiece Size: NPS 1-1/2 and standard length to top of bowl.

2.5 TOILET SEATS

A. Toilet Seats:

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

    a. American Standard Companies, Inc.
    b. Bemis Manufacturing Company.
    c. Church Seats.
    d. Kohler Co.
    e. Olsonite Corp.
    f. Sperzel.

2. Description: Toilet seat for water-closet-type fixture.

    a. Material: Molded, solid plastic with antimicrobial agent.
    b. Configuration: Open front without cover.
    c. Size: Elongated.
    d. Hinge Type: CK, check.
    e. Class: Heavy-duty commercial.
    f. Color: White.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

    a. Engineered Brass Co.
    b. McGuire Manufacturing Co., Inc.
    c. TCI Products.
    d. TRUEBRO, Inc.
    e. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

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.

2.7 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

6. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

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

C. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

2.8 WATER CLOSETS

A. Water Closets:

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

   a. Crane Plumbing, L.L.C./Fiat Products.
   b. American Standard Companies, Inc.
   c. Kohler Co.
   d. Zurn.

2. Description Accessible, wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
3. See fixture schedule on drawings for complete description of fixtures and accessories.

   a. Style: One piece.

      1) Bowl Type: Elongated with siphon-jet design.
      2) Design Consumption: 1.28 gal. /flush (6 L/flush).
      3) Trip Mechanism: Hardwired Sensor actuator.
      4) Color: White.

   b. Supply: NPS 1 1/4 chrome-plated brass or copper with wheel-handle stop.

2.9 LAVATORIES

A. Lavatories:

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

   a. American Standard Companies, Inc.

b. Eljer.
c. Kohler Co.
d. American Standard Companies, Inc.
e. Crane Plumbing, L.L.C./Fiat Products.

2. Description: See fixture schedule on drawings for complete description of fixture and accessories.

2.10 SERVICE SINKS

A. Service Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: See fixture schedule on drawings for complete description of fixture and accessories. Retain one of two lists below.

a. BK Industries
b. Kohler Co.
c. Crane Plumbing, L.L.C./Fiat Products.
d. Mustee
e. Fiat
f. Kohler Co.

2. Description: Flush-to-wall, floor-mounting, one piece molded resin cellular fixture. See fixture schedule on drawings for complete description of fixture and accessories.

a. Shape: Square.
b. Size: 20 inches wide x 24 inches Length and 13” deep.
c. Support: heavy gauge steel legs with levelers
d. Height: 34 inches with dropped front.
e. Rim Guard: N/A.
f. Color: white.
g. Polished or rough, chrome-plated, solid-brass faucet with wall brace is recommended. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.
h. Drain: Grid with NPS 3 outlet

2.11 SERVICE BASINS

A. Service Basins:

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

a. Acorn Engineering Company.
b. Crane Plumbing, L.L.C./Fiat Products.
c. Florestone Products Co., Inc.
d. Precast Terrazzo Enterprises, Inc.
e. Stern-Williams Co., Inc.
f. Mustee, E. L. & Sons, Inc.

g. Zurn Plumbing Products Group; Light Commercial Operation.

2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard. See fixture schedule on drawings for complete description of fixture and accessories.

a. Shape: Square.
b. Size: 24 by 24 inches.
c. Height: 12 inches with dropped front.
d. Rim Guard: On all top surfaces.
e. Color: Not applicable.
f. Drain: Grid with NPS 3 outlet.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 INSTALLATION

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

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

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

E. Install counter-mounting fixtures in and attached to casework.

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

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

1. Exception: Use ball, if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

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

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

J. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

K. Install toilet seats on water closets.

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

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

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

O. Install traps on fixture outlets.

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

P. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

Q. 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.

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.

3.6 CLEANING

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

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

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

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

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

END OF SECTION 22 40 00

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SECTION 22 45 00
EMERGENCY PLUMBING FIXTURES

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 emergency plumbing fixtures:

1. Combination units.

B. Related Sections include the following:

1. Specification 22 11 19 "Supply Piping Specialties for Plumbing" for backflow preventers.
2. Specification 22 13 19 "Drain Piping Specialties for Plumbing" for floor drains.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.

D. Tepid: Moderately warm.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Operation and Maintenance Data: For emergency plumbing fixtures to include in maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

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

PART 2 - PRODUCTS

2.1 COMBINATION UNITS

A. Combination Units:

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

    a. Bradley Corporation.
    b. Guardian Equipment Co.
    c. Haws Corporation.
    d. Speakman Company.
    e. Sting Ray

2. Description: Plumbed, accessible, freestanding, with emergency shower and eye/face wash equipment.

    a. Piping: Galvanized steel.

        1) Unit Drain: Outlet at side near bottom.

    b. Shower Capacity: Deliver potable water at rate not less than 20 gpm for at least 15 minutes.
    c. Eyewash Equipment: With capacity to deliver potable water at rate not less than 0.4 gpm for at least 15 minutes.

2.2 WATER-TEMPERING EQUIPMENT

A. Water-Tempering Equipment:

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

    a. Armstrong International, Inc.
    b. Bradley Corporation.
    c. Encon Safety Products.
    d. Haws Corporation.
    e. Lawler Manufacturing Co., Inc.
    f. Leonard Valve Company.
    g. Powers, a Watts Industries Co.
    h. Speakman Company.

i. Therm-Omega-Tech, Inc.
j. Western Emergency Equipment.

2. Description: Factory-fabricated, hot- and cold-water-tempering equipment with thermostatic mixing valve.

a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

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

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Valves are specified in Specification 22 05 00 "Common Work Results for Plumbing."

1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency plumbing fixture.
2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Dielectric fittings are specified in Specification 22 05 00 "Common Work Results for Plumbing."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Thermometers are specified in Specification 22 05 23 "Meters and Gages for Plumbing Piping."

G. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Escutcheons are specified in Specification 22 05 00 "Common Work Results for Plumbing."

H. Install equipment nameplates or equipment markers on fixtures and equipment signs on water-tempering equipment. Identification materials are specified in Specification 22 05 53 "Identification for Plumbing."

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 hot- and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing 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. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities and temperatures.

B. Electrical-Component Testing: After electrical circuitry has been energized, test for compliance with requirements.

1. Test and adjust controls and safeties.

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

D. Report test results in writing.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION 22 45 00

SECTION 23 05 00
COMMON WORK RESULTS 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 ACCURACY OF DATA AND CONTRACT DRAWINGS

A. The design drawings are diagrammatic and they may not show all physical arrangements, offsets, bends, or elbows which may be required for installation of various materials, equipment, piping, and ductwork systems in allotted spaces. The Contractor shall examine these and other available drawings to determine space limitations and interferences. The Contractor shall be responsible for making any minor changes in location of equipment, pipe and ductwork from that shown on drawings and for all physical details required for installation. Cost for adapting Contractor's work to jobsite conditions shall not be considered as basis of an extra cost to contract. The Contractor shall get approval before proceeding with any change.

B. Elevation of piping, ductwork and equipment indicated on drawings are to be used as guidelines to assist Contractor with installations. Minor changes to these elevations may be necessary to eliminate unforeseen interferences. The Contractor shall get approval before proceeding with any changes in elevations.

C. Information pertaining to new and existing conditions that are described in the specifications or appear on drawings are based on available records. While such data has been collected with reasonable care, there is no expressed or implied guarantee that conditions so indicated are entirely representative of those actually existing or that unlooked for developments may not occur. Such information is merely provided to assist the Contractor in his investigation of conditions.

D. The Contractor must carefully examine the drawings, specifications and project site, and verify all measurements, distances, levels, materials, equipment, etc. before starting work.

E. Drawings shall not be scaled for determining exact dimensions or location of equipment.

F. Check, verify, and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations, or adjustments necessary to complete work or to avoid interference with other trades.

G. Contractor may install additional piping, fittings, and valves, not shown on drawings, for testing purposes or for convenience of installation or start-up. Where such materials are installed, they shall comply with specifications and shall be sized to be compatible with system design. Remove such installed materials when they interfere with design conditions or as directed by Architect.

H. Except as otherwise specified herein or indicated on drawings, furnish and install all piping, tubing, valves, specialties and supports to connect fixtures and equipment into their respective systems as required for or incidental to the proper operation of the indicated systems. This shall include the following systems:

1. All miscellaneous piping called for on piping and instrument diagrams, regardless of whether or not indicated in the specifications or on the drawings. Reference shall be made to piping and instrument diagrams, control air piping drawings, and manufacturer's equipment drawings to determine full extent or required piping.

1.3 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. Equipment installation requirements common to equipment sections.
8. Painting and finishing.
9. Supports and anchorages.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, 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 chases.

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

F. Except as otherwise defined in greater detail, terms “provide”, “furnish”, and “install” as used in these Contract Documents shall have the following meanings:

1. “Provide” or “provided” shall mean “furnish and install.”
2. “Furnish” or “furnished” does not include installation.
3. “Install” or “installed” does not include furnishing.

G. The following are industry abbreviations for rubber materials:

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

1.5 SUBMITTALS

A. Product Data: None.

1.6 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 HVAC 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.

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. The Contractor or the Contractor’s authorized representative must be present to accept delivery of all equipment and materials furnished by him. The Owner’s personnel will not knowingly accept, unload or store anything delivered to the site for the Contractor’s use. Inadvertent acceptance of delivered items by a representative of the Owner shall not constitute acceptance or responsibility for any of the materials or equipment. It shall be the Contractor’s responsibility to assume all liability for any equipment or materials furnished by him which are delivered to the job site.

C. Storage of materials on the grounds and within the building shall be in strict accordance with instructions of the Owner. Storage of materials within building shall at no time exceed design carrying capacity of the structural system.

D. The Owner assumes no responsibility for materials stored in building or on the site. Each Contractor shall assume full responsibility for all losses or damage due to the storing of his materials.

E. Handle items carefully to avoid damage to components, enclosures and finishes. Follow the manufacturer’s rigging instructions when handling and moving equipment.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC 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 HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08.

1.9 RELATED WORK – UTILITY SERVICES

A. Determine utility connection requirements and include in BASE BID all costs to Owner for utility service.

B. Include costs for temporary service, temporary routing of piping or any other requirements of a temporary nature associated with utility service.

1.10 CODES AND REGULATIONS

A. All codes and regulations of Federal, State, and Local Authorities and utility companies shall become part of this specification and must be adhered to where they exceed requirements as shown on the drawings or stated in the specifications, without additional cost to the Contract.

1.11 CONTINUITY OF EXISTING SERVICES

A. Do not interrupt or change existing services without prior written approval. When interruption is required, coordinate length of service time with Owner to minimize disruption of occupant activities.

1.12 OPERATING AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall provide operating and maintenance instruction manuals covering each and every item of equipment and devices furnished or erected by the Contractor prior to "Substantial Completion" as required by Division 1.

B. Each separate manual shall consist of the following:

1. Neatly typewritten table of contents including contractor's name, address and telephone number; list of each product referenced in manual; and name, address and telephone number of installing contractor and maintenance contractor for each product.
2. Tabbed sections of catalog data and literature for each product including model number, description and component parts; operating procedures; maintenance procedures; servicing and lubrication schedules; description of sequence of operations; parts lists; illustrations, assembly drawings and diagrams required for maintenance; any additional drawings, diagrams, charts or written text which may

be required to supplement product data for particular installation; certified test and balance report; list of control point labels, and wiring diagrams.

3. Copy of warranty, bond and/or service contract issued for each product including an information sheet for operations personnel with proper procedures in event of a product failure and instances which might affect validity of warranties or bonds.
4. Full size sheets, if required, shall be folded into special holding pockets. Faxed, handwritten, or illegible materials are not acceptable.

C. Prior to final inspection or acceptance, fully instruct designated facility operating and maintenance personnel on operation, adjustment and maintenance of products, equipment and systems. Review contents of operating and maintenance manual with personnel in full detail to explain all aspects of operations and maintenance.

1.13 PROTECTION OF ROOF

A. Contractors are cautioned that they must exercise extreme care in any activity involving contact with any installed roof membrane.

B. Construct protective plywood (3/4 in. thick) runways across the roof for moving, setting, and installing equipment and piping systems. No activity on the roof will be permitted without this protection. Start runways at the point of origin of any equipment placed on roof and terminate at the point of installation on curb or base. At completion of work, or when directed by the Owner, completely remove, neatly and cleanly, without damage to roofing system, these protective items and runways.

C. Any and all repairs necessary to bring the roofing system to its original condition shall be made by an approved Roofing Contractor and paid for by the Contractor responsible for the damage.

1.14 WORK COORDINATION

A. All Trades shall work in cooperation with each other and fit their work into the structure as job conditions may demand. All final decisions as to right-of-way and run of pipes and ducts, etc. shall be made by the Owner. In general, priority shall be arranged as follows: (in order of preference)

1. Recessed lighting fixtures
2. Piping which must be drainable
3. Sheet metal ductwork
4. Lighting fixtures
5. Plumbing waste lines, downspouts, vents and sprinkler piping
6. Gravity water lines
7. Heating hot lines
8. Refrigerant lines
9. Natural Gas
10. Plumbing water and air lines
11. Electrical conduit
12. Control wiring conduit

1.15 INSPECTION

A. The Contractor shall verify the location of underground service, utilities, structures, etc., which may be encountered or be affected by his work and shall be responsible for any damage caused by neglect to provide proper precautions or protection.

B. Any work that is to be concealed, such as inside walls, above ceilings, soffits, shall be inspected by Owner or Architect/Engineer prior to concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 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.

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 (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

1. Available Manufacturers:

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. Available Manufacturers:

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. Available Manufacturers:

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. Available Manufacturers:

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. Available Manufacturers:

    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. Available Manufacturers:

    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: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 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.

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, Stamped-Steel Type: With spring clips and chrome-plated finish.

D. Split-Plate, Stamped-Steel Type: With concealed hinge, spring clips, and chrome-plated finish.

2.8 SEALANTS

A. Reference Division 7 specification for sealant requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify elevations and measurements prior to installation of materials.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 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. Full lengths of pipe shall be used. Short lengths and couplings will not be permitted.

L. Where more than one pipe material specification or valve is allowed for particular service, the Contractor is required to use one and only one of the pipe materials specified throughout project. Two or more different piping materials or valves for same service will not be allowed unless indicated otherwise on drawings or specified herein.

M. Independently support piping so that its weight shall not be supported by the equipment to which it is connected.

N. Size reduction shall be made using reducing fittings; bushings are not acceptable.

O. Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.

P. "Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (½) the diameter of the main.

Q. Cover ends of piping during installation to keep inside of piping clean.

R. Piping shall not be routed through electrical rooms or telecommunication rooms or transformer vaults, or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

S. Use only wrenches having square flat jaws, or non-metallic strap wrenches on brass specialties; wrench marks not permitted.

T. Select system components with pressure rating equal to or greater than system operating pressure.

U. 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. Insulated Piping: One-piece, stamped-steel type with spring clips.
    c. Bare Piping at Wall Penetrations in Finished Spaces: One-piece, stamped-steel type.
    d. 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.
    e. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and spring clips.
    f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with spring clips.

V. Sleeves are not required for core-drilled holes thru solid concrete walls.

W. 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. Steel Pipe Sleeves: For pipes smaller than NPS 6.

4. Seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

X. 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. 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.

Y. 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 07 for materials.

Z. Verify final equipment locations for roughing-in.

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

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 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. 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.

F. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.5 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 HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

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

3.6 PAINTING

A. Painting of HVAC systems, equipment, piping and components is specified in Division 09.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

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

END OF SECTION 23 05 00

SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC 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 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

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 INDUCTION 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. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. 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.

2.4 POLYPHASE INDUCTION MOTORS WITH ADDITIONAL REQUIREMENTS

A. 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.
5. Shaft Grounding: Provide bearing protection grounding rings to bleed current from the motor shaft to the motor casing.

2.5 SINGLE-PHASE INDUCTION 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.

2.6 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Description: Electrically commutated, adjustable speed, brushless direct current (BLDC) motor.

B. Constant CFM, constant torque

C. Multi-Speed: Shall be speed controllable down to 20% of full speed using a 0-10 VDC signal.

D. Efficiency: Energy efficient, as defined in NEMA MG 1.

E. Service Factor: 1.00

PART 3 - EXECUTION (Not Used)

END OF SECTION 23 05 13

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SECTION 23 05 14
VARIABLE FREQUENCY DRIVES

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 COORDINATION

A. Coordinate features of variable frequency drives, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.
2. Ratings and characteristics of supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.

1. Include dimensions and finishes for VFDs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the following as City of Madison's preferred variable frequency drive equipment supplier and is to be a part of the Section 23 09 00 Contractor's scope of work for this project.

1. Danfoss, VLT Series.

2.2 DESIGN AND CONSTRUCTION

A. The unit shall be variable torque, modular design for control of the motors as specified in Division 23 and rated at the motor full load nameplate amps.

B. The unit shall be U.L. listed, solid state, microprocessor-based with a pulse width modulated (PWM) output wave form (none others are acceptable).

C. The VFD shall employ a full wave bridge rectifier and capacitors to minimize the ripple of the rectified voltage to maintain near constant DC voltage. Insulated gate bipolar transistors (IGBT's) shall be employed as the output switching device.

D. The VFD package shall contain the equivalent of 5% impedance to reduce harmonic distortion. The 5% equivalent impedance shall be provided in the form of a DC bus choke, an input AC line reactor in each phase, or a combination of the two methods.

E. Control circuitry shall be plug-in, plug-out modular basis with a corrosion resistant coating on printed circuit boards.

F. Units to be suitable for an operating environment from 0°C to 40°C temperature and humidity up to 90% non-condensing.

G. Electrically and physically isolate control circuitry and conductors from power circuitry and power conductors. Control conductors and power conductors shall not be run in the same pathway.

H. The unit enclosure shall be NEMA 1 as required for the application minimum and all components shall be fully factory assembled and tested prior to leaving the manufacturing facility.

I. Include the following operating and monitoring devices mounted on the front cover:

1. A disconnect switch or circuit breaker to de-energize the drive circuit with door interlocked handle and lock-open padlocking provisions.
2. Operating mode selector switch marked "hand-off-auto".
3. Manual speed adjustment via keypad, mounted on the door.

2.3 PERFORMANCE REQUIREMENTS

A. Units shall be suitable for input power of electrical system as scheduled on the drawings ±10%, 3 phase, 60 Hertz nominal.

B. Use a current limiting control device to limit output current to 110% continuous for one minute; also refer to Protection Features in this section. Full load output current available from drive shall not be less than motor nameplate amperage. The full load amp rating of the VFD shall not be less than the values indicated in the NEC Table 430-150.

C. Output power shall be suitable for driving standard NEMA B design, three phase alternating current induction motors at full rated speed with capability of 6:1 turndown.

D. Additional performance capabilities to include the following:

1. Ride through a momentary power outage of 15 cycles,
2. Start into a rotating load without damage to drive components or motor,
3. Capable of automatic restart into a rotating load after a preset, adjustable time delay following a power outage
4. Input power factor: Min 0.95 throughout the speed range
5. Minimum efficiency: 95% at 100% speed, 85% at 50% speed

2.4 CONTROL FEATURES

A. Use control circuits compatible with input signal from temperature control system in the automatic mode and from manual speed control in the manual mode. Vary motor speed in response to the input control signal. Include components necessary to accept the signal from the temperature control system in the form that it is sent.

B. Include the following additional control features:

1. Hand-Off-Automatic (HOA) selector switch to select local or remote start/stop and speed control.
2. Analog input, selectable 0-10v or 4-20 mA, for automatic control from the temperature control system.
3. Local speed control at the VFD.
4. Adjustable acceleration and deceleration rate so that the time period from start to full speed and from full speed to stop can be field adjusted.
5. Adjustable minimum and maximum speed settings for both automatic and manual modes of operation.
6. Field adjustment of minimum and maximum output frequency.
7. Two (2) sets of programmable form “C” contacts for remote indication of variable frequency drive condition. Note: default programming to be set for “Drive Run & Fault”.
8. Illuminated display keypad.
9. External Fault indicator.
10. One (1) input for a N.O. dry contact type input for a 2-wire remote start/stop.
11. One (1) input for a N.C. dry contact type input for external faults: (freezestats, fire alarm, smokes, etc).
12. One (1) N.O. dry contact output for proving motor status. This output shall be programmed to detect belt or coupling break that would remove the load from the motor. The dry contact will open on loss of load or VFD being off.
13. PID control loop capable of VFD control from an external device connected to a VFD analog input.

C. The VFD controller shall convert VFD information into the BACnet MSTP protocol that will be compatible with the building direct digital energy management system (EMS) supplied on the project. This output shall be through a serial interface port capable of two-way communication with the building EMS provided on this project. Final connection shall not require any additional intermediate gateway devices to provide throughput of data. The following data shall be provided at a minimum:

1. Fault condition
2. Speed
3. Amperage
4. Frequency

5. Voltage

2.5 PROTECTION FEATURES

A. Use electronic protection circuitry in the power circuits to provide an orderly shutdown of the drive without blowing fuses or tripping circuit breakers and prevent component loss under the following abnormal conditions:

1. Activation of any safety device;
2. Instantaneous overcurrent and/or over voltage of output;
3. Power line overvoltage and undervoltage protection;
4. Phase loss;
5. Single and three phase short circuiting;
6. Ground faults;
7. Control circuit malfunction;
8. Overtemperature; and
9. Output current over limit.

B. Provide the following additional protective features:

1. Input transient overvoltage protection up to 3000 volts per ANSI 37.90A;
2. DC bus fusing or other electronic controls which limit the rate of rise of the DC bus current and de-energizes the drive at a predetermined current level;
3. Fusing for the control circuit transformer;
4. Grounded control chassis; and

2.6 DIAGNOSTICS

A. Provide an English character display (no error codes) with indicators for the following:

1. Phase loss
2. Ground fault
3. Overcurrent
4. Overvoltage
5. Undervoltage
6. Over temperature
7. Overload
8. DC bus status

2.7 QUALITY ASSURANCE TESTS

A. Use a factory heat stress test to verify proper operation of all functions and components under full load.

B. Field performance test of variable frequency drives to determine compliance with this specification will be performed at the Owner's discretion and may include any specified feature, including operation of protective devices through a simulated fault. Contractor will pay for initial testing. Should drive be found deficient by this testing, drive manufacturer will be required to make any and all changes necessary to bring unit(s) into compliance with the specified performance and demonstrate this performance by retesting. Cost of changes and retest will be by this contractor.

C. Variable frequency drive manufacturer or designated representative to perform a field test of each drive, in the presence of the Owner's representative, for the following items:

1. Provide general inspection to verify proper installation;
2. Demonstrate drive reaction to simulated power interruptions of two seconds and sixty seconds;

2.8 AC INPUT LINE REACTORS

A. When needed to comply with the requirement for 5% equivalent impedance, furnish and factory install AC input line reactors.

B. Line reactors shall be installed in each phase of the AC input side of the VFD and mounted within a common enclosure with the VFD.

C. Line reactor shall be a three-phase inductor, iron core, 600V, Class H insulation, 115-degree C rise, copper windings with screw type terminal blocks.

PART 3 - EXECUTION

3.1 VARIABLE FREQUENCY DRIVES

A. Install where indicated on drawings and in accordance with approved submittals and manufacturer's published recommendations. Installation to be by the Division 26 Electrical contractor.

B. Input power wiring shall be installed in a separate conduit, output power wiring shall be installed in a separate conduit and control wiring shall be installed in a separate conduit. Do not mix input power, output power, or control wiring in a common conduit. Separate conduits for input and output power wiring shall be provided for each motor. Input and output power wiring for more than one motor shall not share a common conduit. Power wiring shall be furnished and installed by the Div. 26 contractor. If provided, do not mount output line filter above the drive.

C. Control signal for drive will be provided under Division 23.

D. Temperature Control Contractor will furnish variable frequency drives and install the required temperature control wiring in metal conduit and in accordance with Division 26 of this specification.

3.2 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. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect 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 VFD. Remove front panels so joints and connections are accessible to portable scanner.
    b. 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.

E. VFDs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.3 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.

3.4 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 VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

END OF SECTION 23 05 14

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SECTION 23 05 16
EXPANSION FITTINGS AND LOOPS 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 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.

1.3 ACTION SUBMITTALS

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

B. Delegated-Design Submittal: For each flexible-hose packless expansion joints, provide anchor and alignment guide as required to comply with performance requirements and design criteria, 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, if required.
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 flexible-hose packless expansion joint.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:

1. Basis-of-Design Product: The design is based on the following:

    a. Flex-Hose Co., Inc. (Tri-Flex Loop)

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

    a. Mason Industries, Inc.
    b. Metraflex Company (The).

3. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.

    a. Product shall absorb and compensate multi-plane pipe movements.
    b. Designed for pressure testing to 1.5 times their maximum rated working pressure and a minimum 4:1 (burst to working) safety factor.
    c. Provide hanger assembly kit shall be used to support flexible-hose.
    d. Flexible pipe loop shall be capable for multi-plane movements (X, Y, and Z), plus rotation about those axes simultaneously as well as reduce piping stress.

4. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
5. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

    a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.

6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with weld end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.

2.2 JOINTS

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

1. Anvil International, Inc.
2. Victaulic Company.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Seven, flexible type for steel-pipe dimensions. Include ferrous housing sections, EPDM gasket suitable for cold and hot water, and stainless steel bolts and nuts.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

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

    a. Adsco Manufacturing LLC.
    b. Advanced Thermal Systems, Inc.
    c. Hyspan Precision Products, Inc.
    d. Mason Industries, Inc.
    e. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider 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 EXPANSION-JOINT INSTALLATION

A. Install flexible-hose packless pipe loop expansion joints of sizes matching sizes of piping in which they are installed.

B. Install flexible-hose packless pipe loop expansion joints per manufacturer's guidelines per delegated design submittal for anchors and guides installation requirements.

C. Install grooved-joint expansion joints to grooved-end steel piping

3.2 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.

3.3 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.

H. Number and spacing of guides shall be per pipe guide manufacturer’s recommendations.

END OF SECTION 23 05 16

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SECTION 23 05 19
METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. Miljoco Corporation
    b. Trerice, H. O. Co.
    c. Weiss Instruments, Inc.
2. Standard: ASME B40.200.
3. Case: Aluminum with enamel or powder coat finish; 9-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: plastic.
8. Stem: brass and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
9. Connector: 1¼ 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.

2.2 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. Socket: Stainless steel separable sockets.
6. Type: Stepped shank unless straight or tapered shank is indicated.
7. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
8. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
9. Bore: Diameter required to match thermometer bulb or stem.
10. Insertion Length: Length required to match thermometer bulb or stem.
11. Lagging Extension: Include on thermowells for insulated piping and tubing.
12. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

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

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Miljoco Corporation.
    d. Trerice, H. O. Co.
    e. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    f. Weiss Instruments, Inc.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); 304 stainless steel; 4½-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: plastic.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

A. Valves: Stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

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

1. Flow Design, Inc.
2. Miljoco Corporation.
3. Peterson Equipment Co., Inc.
4. Trerice, H. O. Co.
5. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
6. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: 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: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe 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 direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install remote-mounted pressure gages on panel.

H. Install valve and snubber in piping for each pressure gage for fluids.

I. Install test plugs in piping tees.

J. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.

K. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Before and after gas service regulators.

3.2 CONNECTIONS

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

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 SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

B. Scale Range for Medium Pressure Natural Gas: 0-10 psi for upstream of GPRV.

C. Scale Range for Low Pressure Natural Gas: 0-30" WC for downstream of GPRV.

END OF SECTION 23 05 19

SECTION 23 05 23
GENERAL-DUTY VALVES 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 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.

1.3 ACTION SUBMITTALS

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

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.

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 ball valves open to minimize exposure of functional surfaces.
4. Set butterfly valves closed or slightly open.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Water System Valves

1. All water system valves to be rated at not less than 125 psig water working pressure at 240°F unless noted otherwise.

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 6 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 5and smaller except plug valves.
4. Chainwheel: Device for attachment to valve gear actuator or handwheel; with chain for mounting height, for valves located 12 feet or higher from floor.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
2. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Threaded: With threads according to ASME B1.20.1.

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

H. The manufacturer's name and valve pressure rating shall appear on the outside of the valve body.

2.2 BRONZE BALL VALVES

A. 2" and smaller: Two-piece bronze body; threaded or soldered ends, as appropriate to the pipe material; stainless steel or chrome plated brass/bronze ball; conventional port;

glass filled teflon seat; threaded packing gland follower; blowout-proof stem; 600 psig WOG.

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

    a. Apollo 70-100/200 series
    b. Hammond 8301/8311
    c. Milwaukee BA100/150
    d. Nibco T/S 585-70
    e. Stockham S206/216.

3. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Bronze.
    f. Ends: Threaded.
    g. Seats: PTFE or TFE.
    h. Stem: Bronze.
    i. Ball: Chrome-plated brass.
    j. Port: Full.

4. 2½" and over: Ball valves will not be accepted in sizes over 2 inch.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 2" and smaller: Use ball valves; butterfly valves will not be accepted in sizes 2 inch and smaller.

B. 2½" and larger: Use American Valve ball valves for flanged connections in lieu of butterfly valves at all branch services lines.

1. Basis-of-Design Product: Subject to compliance with requirements, provide the following as City of Madison's preferred ball valve manufacturer supplier for 2½" and larger.
    a. American Valve: 4000 Flanged ball valve.
2. Ductile iron body; steel shaft; flanged ball valve with teflon coated stainless steel ball, blow-out proof stem, full port with lockable in full open or closed positions. Rated for 150 WSP 300 WOG.

C. Contractor shall notify A/E in incidents where butterfly valves with chain operators are recommended when valves are more than 20 feet above finished floor.

D. Cast iron body; stainless steel shaft; Teflon, nylatron, or acetal bearings; EPDM resilient seat. Disk to be bronze, aluminum-bronze, nickel plated ductile iron, cast iron with welded nickel edge, or 316 - stainless steel. Pressure rated to 150 psig. Valve assembly

to be bi-directionally bubble tight to 150 psig with no downstream flange/pipe attached. Nylon coated ductile iron discs are not acceptable. Polymid or polyamide coated valves are not acceptable.

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

    a. Centerline series 200
    b. DeZurik BOS-CL
    c. Keystone Fig. 222
    d. Nibco LD2000 (2-1/2”-12”)
    e. Bray Series 31H
    f. Victaulic 300 series (2-1/2”-12”)

2. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 150 psig.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
    e. Seat: EPDM.
    f. Stem: One- or two-piece stainless steel.
    g. Disc: Stainless steel.

2.4 GATE VALVES:

A. 2" and smaller: Use ball valves; gate valves will not be accepted in sizes 2" and smaller.

B. 2½" and larger: Use butterfly valves; gate valves will not be accepted in sizes 2½" and larger.

2.5 GLOBE VALVE

A. Do not use globe valves for water service, except in temperature control applications.

2.6 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball, butterfly, and plug valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, Ductile or cast iron, Cast iron, or Aluminum Bronze, of type and size required for valve. Include zinc coating.

4. Chain: Hot-dip, galvanized steel or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

F. Install valves in strict accordance with valve manufacturer's installation recommendations. Do not support weight of piping system on valve ends.

G. Install all temperature control valves.

H. Properly align piping before installation of valves in an upright position; operators installed below the valves will not be accepted.

I. Install all valves with the stem in the upright position. Valves may be installed with the stem in the horizontal position only where space limitations do not allow installation in an upright position or where large valves are provided with chain wheel operators.

J. Install stem extensions when shipped loose from valve.

K. Prior to flushing of piping systems, place all valves in the full-open position.

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. Install shut-off valves at all equipment, at each branch take-off from mains, and at each automatic valve for isolation or repair.

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

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

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

F. Install chainwheels on operators for ball, butterfly, gate, globe, and plug valves NPS 4 and larger and more than 120 inches above floor. Extend chains to 60 inches above finished floor.

G. Install shutoff valves in all branch lines at or near header and at each automatic valve location.

H. Vents and Drains: All required vents and drains may not be shown on the Contract Drawings. Install ¾-inch nominal size vent and drain valves in piping systems 1-inch and larger. Install line size vent and drain valves in piping systems ¾-inch and smaller. Locate vents at high points of each line and/or branch connection. Locate drains at low points. Use piping materials specified for each service. Cap all vents and drains.

1. Use ball valve with threaded hose adapter and chained cap. Strainer blowdown valves shall be same size as strainer blowdown connection.

I. Butterfly valves installed at the location of a flow sensing device are to have a memory stop.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball or butterfly valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.

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. See drawing valve schedule for valve application requirements.

END OF SECTION 23 05 23

SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

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

1.3 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.

1.4 ACTION SUBMITTALS

A. Product Data: None.

1.5 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. Stainless Steel Pipe Hangers and Supports:

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

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from 304 or 18-8 stainless-steel shapes with MSS SP-58 stainless steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. Flex-Strut Inc.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut Corporation; Tyco International, Ltd.
    g. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted stainless steel channel.
5. Channel Nuts: Formed or stamped stainless steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.4 THERMAL-HANGER SHIELD INSERTS

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

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength. Provide 304 or 18-8 stainless steel pipe shield for top and bottom for outer jacketing.

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

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

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

2.5 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, 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.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from 304 or 18-8 stainless steel structural shapes for Service Lane.

B. Description: Welded, shop- or field-fabricated equipment support made from galvanized steel structural shapes for other areas outside of the Service Lane.

2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, 304 or 18-8 stainless steel structural shapes plates, shapes, and bars; black and galvanized for Service Lane.

B. Structural Steel: ASTM A 36/A 36M, 304 or 18-8 galvanized steel structural shapes plates, shapes, and bars; black and galvanized for other areas outside of the Service Lane.

2.8 CORROSIVE ATMOSPHERE COATINGS

A. Factory coat supports and anchors used in corrosive atmospheres with hot dip galvanizing after fabrication, ASTM A123, 1.5 ounces/square foot of surface, each side. Mechanical galvanize threaded products, ASTM B695 Class 150, 2.0 mil coating. Field cuts and damaged finishes to be field covered with zinc rich paint of comparable thickness to factory coating.

B. Corrosive atmospheres include the following locations:

1. Exterior Locations
2. HVAC Shop Srea
3. Bus Maintenance Area B
4. Bus Circulation/Storage Area.

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, galvanized carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

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

E. Fastener System Installation:

1. Install 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.

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

G. Piping shall be supported independently from ductwork and all other trades.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and vibration 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.

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

K. Install building attachments within precast concrete planks 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. Coordinate with General Contractor for steel plate inserts in precast (hollowcore) planks construction submittal.

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

M. 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.

N. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    b. 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. 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.

4. 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. 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.

3.6 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 for areas other than Service Lane areas.

D. Use stainless steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for Service Lane areas.

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

F. Use thermal-hanger shield inserts for insulated piping and tubing.

G. 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 6, requiring up to 4 inches of insulation.
3. Stainless Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 6, 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 6 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 6.
7. Adjustable, Stainless Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 6.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 6.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 6.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 6.
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 6.
13. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 6, with steel-pipe base stanchion support and cast-iron floor flange or stainless steel plate.
14. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 6, from two rods if longitudinal movement caused by expansion and contraction might occur.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 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.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. 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.
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.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install stainless steel saddles/shields the following types:

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

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

L. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

END OF SECTION 23 05 29

SECTION 23 05 48.13
VIBRATION CONTROLS 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 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 type required.

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 device.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.3 QUALITY ASSURANCE

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

1.4 VIBRATION CONTROL DESIGN CRITERIA

A. Isolate all motor driven and reciprocating mechanical equipment unless otherwise noted, from building structure, and from systems which they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow ASHRAE Application Handbook - Sound and Vibration Control, latest edition or manufacturer's recommendations for isolation selection.

B. Select and locate isolators to produce uniform loading and deflection. Use minimum of four isolators to support each piece of equipment.

C. Select vibration isolation devices based on lowest operating speed.

D. Vibration Criteria:

1. All rotating equipment shall operate at speeds less than 80% of their true critical speed. Unless otherwise required, equipment shall be balanced according to the recommendations given in the following schedules.
2. Vertical vibration of rotating equipment shall not be greater than levels indicated. Vibration shall be measured on equipment or steel-frame equipment base when equipment is mounted on its vibration isolation mounts. If equipment has inertia base, allowable vibration level is reduced by ratio of equipment weight alone to equipment weight plus inertia base weight.

Equipment Speed RPM	Maximum Allowable Vibration Displacement Peak-to-Peak (mil)
Under 600	4
600 to 1000	3
1000 or 2000	2
over 2000	1

3. Following field installation, each fan over 5 HP shall be balanced in accordance with the following schedule:

   a. Centrifugal fans - 25 mil/sec, rms

4. Final in-field balance shall be measured with each fan over 5 HP installed on springs specified for unit. Fans shall be loaded with design static pressure. Measurement shall be carried out in vertical axis at each corner of frame supporting fan/motor assembly.

PART 2 - PRODUCTS

2.1 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

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

   a. Kinetics Noise Control, Inc.
   b. Mason Industries, Inc.
   c. Vibration Eliminator Co., Inc.
   d. Vibration Mountings & Controls, Inc.

2. Frame: 304 or 18-8 stainless steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.

3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.2 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

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

a. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Vibration Eliminator Co., Inc.
d. Vibration Isolation.
e. Vibration Mountings & Controls, Inc.

2. Frame: 304 or 18-8 stainless 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. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation 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 VIBRATION CONTROL 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 Division 03.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Install vibration isolation devices for motor driven equipment in accordance with the manufacturer's installation instructions.

D. Do not allow installation practices to short circuit any isolation device.

3.3 CORROSIVE ATMOSPHERE AREAS

A. Factory coat supports and anchors used in corrosive atmospheres with hot dip galvanizing after fabrication, ASTM A123, 1.5 ounces/square foot of surface, each side. Mechanical galvanize threaded products, ASTM B695 Class 150, 2.0 mil coating. Field cuts and damaged finishes to be field covered with zinc rich paint of comparable thickness to factory coating.

B. Corrosive atmospheres include the following locations:

1. Exterior Locations
2. HVAC Shop Area
3. Bus Maintenance Area B
4. Bus Circulation/Storage Area.

END OF SECTION 23 05 48.13

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

A. Product Data: None.

1.3 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 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2½ by ¾ inch.
6. Minimum Letter Size: ¼ inch for name of units if viewing distance is less than 24 inches, ½ inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

2.2 PIPE LABELS

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

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

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1½ inches high.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

C. Pipe Label Color Schedule:

1. Natural Gas: Yellow background color with black letters.

END OF SECTION 23 05 53

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SECTION 23 05 93
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 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Certified TAB reports.

1.4 QUALITY ASSURANCE

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

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

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

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

C. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.

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

1.5 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

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

E. Examine equipment performance data including fan 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.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and filters and verify that bearings are greased, direct drive are alignment, and equipment with functioning controls is ready for operation.

I. Examine new and existing strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

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

K. Examine existing system pumps to ensure absence of entrained air in the suction piping.

L. Examine operating safety interlocks and controls on HVAC equipment.

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

3.2 PREPARATION

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

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Existing and new hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 19 "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 (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

C. Check airflow patterns from the outdoor-air louvers and dampers and exhaust-air dampers through the supply-fan discharge dampers.

D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

E. Verify that motor starters are equipped with properly sized thermal protection.

F. Check dampers for proper position to achieve desired airflow path.

G. Check for airflow blockages.

H. Check condensate drains for proper connections and functioning.

I. Check for proper sealing of make-up air-handling-unit components.

J. Verify that air duct system is sealed as specified in Section 23 31 13 "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. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
    b. Measurements for Normal and Bus Mode Operations per Section 23 09 93 “Sequence of Operations for HVAC Controls” and per Mechanical drawings for Control Schematics M-800 Series.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.

3. Measure static pressure across each component that makes up a make-up units, air-to-air energy recovery units and other air movement equipment and treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as heat-recovery equipment, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Owner 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.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

    a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers serving diffusers, registers and grilles.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at existing pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in existing expansion tank in existing boiler room.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal unit’s valves are kept open.
6. Set system controls so automatic valves are wide open to existing boilers.
7. Check existing pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at existing hot water pumps in existing boiler room. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the existing pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

    a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Owner.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

    a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower of existing pump. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure existing pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Check settings and operation of each safety valve. Record settings.

3.8 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

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

3.9 PROCEDURES FOR SPLIT-SYSTEM CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.

B. 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.

3.11 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.

2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and existing pump performance forms including the following:

    a. Settings for outdoor and exhaust-air dampers.
    b. Conditions of filters.
    c. Other system operating conditions that affect performance.

D. Air-to-Air Energy Recovery Test Reports: For energy recovery units with gas fired duct furnace 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. 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.

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Gas Furnace Duct Heater static-pressure differential in inches wg.
g. Static Plate HX static-pressure differential in inches wg.
h. ERV entering-air, dry-bulb temperatures in deg F.
i. ERV leaving-air, dry-bulb temperatures in deg F.
j. ERV outside-air, dry-bulb temperatures in deg F.
k. ERV exhaust-air, dry-bulb temperatures in deg F.
l. Outdoor airflow in cfm.
m. Exhaust airflow in cfm.
n. Outdoor-air damper position.

E. Apparatus-Duct Furnace Test Reports:

1. Duct Furnace Data:

a. System identification.
b. Location.
c. Duct furnace type.
d. Make and model number.
e. Face area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Entering-air, dry-bulb temperatures in deg F.
e. Leaving-air, dry-bulb temperatures in deg F.
f. Gas pressure on GPR, in inches wg.

F. Make-Up Unit’s Gas 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 air flow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

G. Fan Test Reports: For supply, exhaust and fume extractor 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.

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.

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.

H. Round, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and make-up 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 air flow rate in cfm.
    h. Indicated velocity in fpm.
    i. Actual air flow rate in cfm.
    j. Actual average velocity in fpm.
    k. Barometric pressure in psig.

I. Existing 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.

3.13 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

    a. Measure airflow of at least 10 percent of air outlets.
    b. Measure water flow of at least 5 percent of terminals.
    c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
    d. Verify that balancing devices are marked with final balance position.
    e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, Owner Project Representative may request that a final inspection be made for verification.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Owner Project Representative.
3. Owner Project Representative may randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner Project Representative may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

END OF SECTION 23 05 93

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SECTION 23 07 19
HVAC 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 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).

1.3 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 and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing 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. Install insulation in accordance with MICA National Commercial & Industrial Insulation Standards.

1.4 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.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 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" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation (Type I5): Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

    a. Aeroflex USA, Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2. Flexible closed cell, minimum nominal density of 5.5 lbs. per cu. ft., thermal conductivity of not more than 0.28 at 75 degrees F, maximum water vapor permeability of 0.08 perm-in, maximum water absorption of 1% by weight, rated for service range of -20 degrees F to 220 degrees F.

G. Mineral-Fiber, Preformed Pipe Insulation (Type I2):

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

    a. Fibrex Insulations Inc.; Coreplus 1200.
    b. Johns Manville; Micro-Lok.
    c. Knauf Insulation; 1000-Degree Pipe Insulation.
    d. Manson Insulation Inc.; Alley-K.

e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Thermal conductivity of not more than 0.23 at 75 degrees F.

2.2 INSULATING CEMENTS

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

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

a. Ramco Insulation, Inc.; Super-Stik.

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

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

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

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

B. Adhesives, sealants and protective finishes shall be as recommended by insulation and jacket manufacturer for applications specified.

C. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesives, sealants, mastics and protective finishes shall be as recommended by insulation and jacket manufacturer for applications specified.

2.5 SEALANTS

A. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Adhesives, joint sealants and flashing sealants and protective finishes shall be as recommended by insulation and jacket manufacturer for applications specified.

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.

2. Stainless-Steel Jacket (J4): ASTM A 167 or ASTM A 240/A 240M.

   a. Factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket drawing schedules.
   c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
   d. Moisture Barrier for Outdoor Applications: 2.5-mil-thick polysurlyn.
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

   a. ABI, Ideal Tape Division; 428 AWF ASJ.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

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

a. ABI, Ideal Tape Division; 491 AWF FSK.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corporation; 110 and 111.
d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.9 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

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

3.2 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

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-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center.
3. Overlap jacket longitudinal seams at least 1½ inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches on center.

    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 beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.
7. Unions
8. Strainers

Q. In systems with rigid insulation, slip joints shall be installed every 25-30 feet for thermal expansion. They shall overlap and be caulked according to the jacket manufacturer's installation recommendation. On cold piping, flexible fiberglass insulation shall separate the rigid insulation pieces at the slip joint.

3.4 PENETRATIONS

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

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

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

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. 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 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. Finish exposed surfaces shall be a metal jacket.

E. When insulating control valves, strainers, and any other devices requiring frequent access, the insulation shall be fit in such a way that there is an access section which can be readily removed and replaced without damaging adjacent insulation. If a different insulating material is used for boxing in control valve assemblies, etc., the thickness of the insulation shall be adjusted to provide the specified thermal resistance.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches on center.
4. For insulation with factory-applied jackets on below-ambient surfaces, 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 mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1½-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches on center and at end joints.

3.9 FINISHES

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

B. Do not field paint stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, six locations of fittings, and three locations of valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

D. All reinstallation of insulation removed for inspection shall be performed at no additional cost to the Contract.

E. Any discovered deviation from the specified materials and methods shall be considered cause for spot-check dismantling of Work to be performed during the preceding day's work. If further deviations are so discovered, the day's Work proceeding that day may be requested to be checked. All dismantling and reinstallation shall be performed at no additional cost to the Contract.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
2. Piping unions for systems not requiring a vapor barrier.

3.12 PIPING INSULATION SCHEDULE

Service	Pipe Size	Insulation Type	Insulation Thickness	Field Applied Jacket Type	Field Applied Jacket (Outdoor Locations)
Heating Hot Water	1-1/2" and smaller	I2	1.5"	J4	J4
	2" to 3"	I2	2"	J4	J4
Refrigerant Suction 40F to 20F	1-1/4" and smaller	I5	1"	J4	J4
	1-1/2" and larger	I5	1.5"	JR	J4

END OF SECTION 23 07 19

SECTION 23 08 00
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.5 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.7 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from rooftop equipment for heat generation and ductless refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R systems, subsystems, and equipment Testing Procedures

A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence and Operations for HVAC Controls." Assist the CxA with preparation of testing plans.

B. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

C. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas and hot-water systems and equipment at the

direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air and hydronic distribution systems; special exhaust; energy recovery and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

F. Vibration Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation controls.

END OF SECTION 23 08 00

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SECTION 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections include the following:

1. Section 23 05 19 "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
2. Section 23 09 24 "Direct Digital Control System for HVAC" for requirements that relate to this Section.
3. Section 23 09 93 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

C. Furnish and install all labor, materials, equipment, electronic interfaces and actuation devices, apparatus, software, services, permits and supervision, and all permanent and temporary facilities necessary to provide complete and proper working Direct Digital Control system as indicated on the drawings, called for in the specifications or required by job conditions. Drawings are diagrammatic only. Provide any equipment and labor not specifically referred to herein or on the drawings that are required to meet the functional intent, such as repeaters, routers, bridges, and gateways.

1.3 SYSTEM DESCRIPTION

A. System is to use direct digital control with electric actuation for air handling units; direct digital control with electric actuation for room temperature and terminal airflow control.

1.4 DEFINITIONS

A. BAS: Building Automation System.

B. DDC: Direct digital control.

C. I/O: Input/output.

D. LAN: Local Area Network.

E. RTD: Resistance temperature detector.

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F.
b. Water Flow: Plus or minus 5 percent of full scale.
c. Water Pressure: Plus or minus 2 percent of full scale.
d. Space Temperature: Plus or minus 1 deg F.
e. Ducted Air Temperature: Plus or minus 1 deg F.
f. Outside Air Temperature: Plus or minus 2 deg F.
g. Temperature Differential: Plus or minus 0.25 deg F.
h. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
i. Airflow (Terminal): Plus or minus 10 percent of full scale.
j. Air Pressure (Space): Plus or minus 0.01-inch wg.
k. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
l. Electrical: Plus or minus 5 percent of reading.

B. Communications protocol:

1. BACnet protocol per the latest version of ASHRAE Standard 135 and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. Engineering units: English.

D. Provide at least 10% spare I/O connections on each controller.

E. Components shall operate within 32 deg F to 122 deg F and 5-85% relative humidity, non-condensing.

1.6 SEQUENCE OF OPERATION

A. Refer to Section 23 09 24 "Direct Digital Control System for HVAC" for requirements that relate to this Section.

1.7 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams for each system showing fans, pumps, coils, dampers, valves, and control devices.

3. Wiring Diagrams: Power, signal, and control wiring. Differentiate between factory and field installed wiring.
4. Wire Tabulation List: wire ID, “to” and “from”, and wire color.
5. Details of control panel faces, including controls, instruments, and labeling.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.

C. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.

D. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

1.8 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Qualification Data: For Installer.

C. Field quality-control test reports.

1.9 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.
5. Programming manuals.
6. Maintenance instructions.
7. Record documents (“as-builts”), including updated schematic diagrams, wiring diagrams, and control sequences.
8. Training documentation.
9. Contact information of service contractor and parts suppliers.

1.10 QUALITY ASSURANCE

A. Installing contractor must be a manufacturer's branch office or an authorized representative of a Direct Digital Control (DDC) equipment manufacturer that provides engineering and commissioning of the DDC equipment. Submit written confirmation of such authorization from the manufacturer. Indicate in letter of authorization that installing contractor has successfully completed all necessary training required for engineering, installation, and commissioning of equipment and systems and that such authorization has been in effect for a period of not less than three years. DDC

equipment may or may not be required to be installed by this contractor as part of the project, but the intent of this quality assurance specification is to ensure that the installing contractor has the capabilities to engineer, install, and commission the field devices supplied under this section for temperature control.

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. Comply with ASHRAE 135 for DDC system components.

D. Comply with the following:

1. UL-916; Energy Management Systems.
2. UL-873; Temperature Indication and Regulating Equipment.
3. UL-864, Subcategories UUKL, UOXX, UDTZ; Fire Signaling and Smoke Control Systems.
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

1.12 COORDINATION

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

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

1.13 WARRANTY

A. Provide warranty on all parts and labor for one year starting at the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 CONTROL SYSTEM

A. Refer to Section 23 09 24 "Direct Digital Control System for HVAC" for requirements that relate to this Section.

2.3 INTERFACE WITH DDC EQUIPMENT

A. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers. Systems which command multiple outputs over a single pair of wires, such as power line carrier systems, are not acceptable.

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-V dc), 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 with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.
8. SPDT Output Relays: Indicate status with an LED.

B. 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.

C. 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.

D. Control Panels:

1. Provide panel enclosures for all DDC controllers and associated function modules. All controls to be in enclosures without exception. Panels will be approved provided all conduit is bonded and grounded.
2. Provide UL listed cabinets for use with line voltage devices.
3. NEMA Rating:

    a. Inside: NEMA-1.
    b. Outside: NEMA-3R or NEMA-4.

4. Constructed of steel or extruded aluminum, with hinged door, keyed lock, and baked enamel finish. Install controls, relays, transducers and automatic switches inside panels. Label devices with permanent printed labels and provide asbuilt wiring/piping diagram within enclosure. Provide raceways for wiring and poly within panel for neat appearance. Provide termination blocks for all wiring terminations. Label outside of panel with panel number corresponding to plan tags and as-built control drawings as well as building system(s) served.
5. Control panels that have devices or terminations that are fed or switch 50V or higher shall enclose the devices, terminations, and wiring so that Personal Protective Equipment (PPE) is not required to service the under 50V devices and terminations within the control panel. As an alternative, a separate panel for only the 50V and higher devices may be provided and mounted adjacent to the under 50V control panel.
6. For panels that have 120VAC power feeds provide a resettable circuit breaker. Provide label within the panel indicating circuit number of 120VAC serving panel
7. Provide a service shutdown toggle switch for each air handling unit system located inside the temperature control panel that will initiate a logical shutdown of the air handling unit system. Label the switch so it is clear which position is shutdown and which is auto.

E. Interface with Other Systems: All hardware and software required to provide the specified interactions with other systems, such as fire alarm, security, and lighting systems.

2.4 ELECTRONIC SENSORS AND TRANSMITTERS

A. General Requirements:

1. Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. For wall, immersion, or duct mounting as required.

    a. Architectural housing for office space mounting.
    b. Weatherproof/sunshield housing for outdoors.
    c. Thermowell housing for water applications.

        1) Non-corrosive fluids below 250 deg F: brass or stainless steel.
        2) Other applications: 300 series stainless steel.

    d. Protective housing for duct mounting.

e. Water and dust tight stainless-steel housing for space sensors located in process areas.

3. The sensor/transducer shall be selected to withstand ambient conditions, including moisture or condensation and transient conditions for temperatures, pressures, etc.
4. Transducers may be supplied as an integral unit with the field sensor, or as part of the controller.
5. The sensor/transducer shall be appropriately selected to most closely match the expected sensing range.
6. Use a transmitter where the sensor is more than 100 feet from its associated controller, there is excessive electrical noise present, or the controller cannot accept direct sensor input, a 4-20mA type.
7. All temperature sensors shall be of the same manufacturer.
8. All pressure transmitters and transducers shall be of the same manufacturer.

B. RTDs and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.
b. MAMAC Systems, Inc.
c. RDF Corporation.

2. Accuracy: Plus or minus 0.2 percent at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
5. Averaging Elements in Ducts: 18 inches long, rigid use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Concealed.
b. Set-Point Indication: Concealed.
c. Thermometer: Concealed.
d. Color: White.
e. Orientation: Vertical.

8. For Service Lane: Terminal unit sensors shall be provided with blank covers and no adjustments.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Pressure Transmitters/Transducers:

1. Manufacturers:

a. BEC Controls Corporation.

b. General Eastern Instruments.
c. MAMAC Systems, Inc.
d. ROTRONIC Instrument Corp.
e. TCS/Basys Controls.
f. Vaisala.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
b. Output: 4 to 20 mA.
c. Building Static-Pressure Range: 0- to 0.25-inch wg.
d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
7. Air Filters: Provide filters on all pressure probes in return or exhaust air systems.

D. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Concealed.
2. Set-Point Indication: Concealed.
3. Thermometer: Concealed.
4. Color: White
5. Orientation: Vertical.

E. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.
2. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.
3. Adjusting Key: As required for calibration and cover screws.

2.5 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

C. 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.

D. 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.

E. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

F. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.6 THERMOSTATS

A. Manufacturers:

1. Erie Controls.
2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
3. Heat-Timer Corporation.
4. Sauter Controls Corporation.
5. tekmar Control Systems, Inc.
6. Theben AG - Lumilite Control Technology, Inc.

B. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF" or "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF" based on system operation.
2. Mount on single electric switch box.

C. Remote-Bulb Thermostats (Type T5): On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

D. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 1 foot (3 m) for every square foot of coil surface.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

E. Thermostat Accessories:

1. Cover: Manufacturer's standard locking covers.
2. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base
3. Insulating Bases: For sensors located on exterior walls.

2.7 FLOW MEASURING STATION

A. Fan inlet piezometers:

1. Where fan inlet piezometers are provided by makeup air manufacturer, these shall be used by the control contractor for air flow measurement. The air velocity transducers shall be provided under this Section and sized as described below.
2. Provide transmitter that will average up to sixteen sensors and provide two field selectable linear analog output signals (4-20mA and 0-10 VDC) proportional to airflow and temperature. Sensor electronic circuitry other than the temperature sensors shall not be exposed to the air stream and shall be protected from moisture to prevent failure.

2.8 ACTUATORS

A. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque. Stroke time for 90-degree rotation 90 seconds or less for major equipment and 6 minutes or less for terminal equipment. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops. Provide pilot positioners.

1. Manufacturers:

   a. Belimo Aircontrols (USA), Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure. Provide operators and pilot positioners with linkages and brackets for mounting on control valve. Design mounting and/or support to provide no more than 5% hysteresis in either direction.
3. Dampers: Size 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.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24-V ac.

8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: 40 to 104 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Run Time: 12 seconds open, 5 seconds closed.
13. Provide external adjustable stops on damper actuators.

2.9 CONTROL VALVES

A. Manufacturers:

1. Belimo Aircontrols (USA), Inc.
2. Honeywell.

B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2½ and Larger: Class 125 iron, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

    a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:

    a. Two Position: Line size.
    b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
    c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.10 DAMPERS

A. Manufacturers:

1. TAMCO (T. A. Morrison & Co. Inc.).

B. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch-minimum thick, galvanized-steel or 0.125-inch-minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch-thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch-diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze or nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.11 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 be at least 100 VA.
3. Transformer shall have both primary and secondary fuses.
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.

B. 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.

2.12 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.13 ANALOG ELECTRONIC INSTRUMENT INDICATORS

A. Panel mount type and at least 2" square.

B. Output: analog needle type or digital with ½" high LED or backlit LCD displays.

C. Marked in appropriate units (Degrees, PSI, %RH, GPM, CFM, etc.) and with appropriate range of values.

D. Minimum accuracy of 1% of scale range.

E. Digital units shall be scaled to show 3 digits plus 1 decimal point.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 SYSTEM DESIGN

A. General Criteria:

1. Size all control devices to properly supply and/or operate and control the apparatus served.
2. Provide control devices suitable for the environment in which they will operate:

    a. All devices shall be constructed to withstand system temperatures and pressures.
    b. Devices used in outdoor ambient conditions shall be constructed to withstand those conditions or shall be suitably weather protected.
    c. Devices in corrosive environments shall be constructed of materials to withstand the effects of that environment.

B. Control Dampers:

1. General:

    a. Unless otherwise indicated, use opposed blade for modulating control dampers and use parallel blade dampers for two position (open/close) dampers and for mixing applications.
    b. All blade linkage hardware shall have a corrosion resistant finish and be readily accessible for maintenance.
    c. Damper construction material shall be the same as the connecting duct material. Exception: Aluminum damper may be used in a galvanized duct system.
    d. Maximum single damper size shall be 48"x48". If total width or height exceeds maximum, use multiple dampers.
    e. Locate actuators outside of the air stream, unless otherwise indicated.

2. Sizing/selection criteria:

a. Two position dampers shall be sized as close as possible to duct size but in no case is the damper to be less than duct area.
b. When damper is part of an intake louver assembly, damper shall be same nominal size as louver unless specified otherwise on drawings.
c. All dampers used for mixing of airstreams shall be sized for 1800 to 2000 feet per minute velocity.

3. All control dampers furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control
4. Damper end switches, where required, shall be independently mounted to the damper drive shaft or auxiliary shaft attached to a damper drive blade. End switches shall be adjusted to prove the damper the position opposite the fail position of the damper actuator unless the control sequence requires a different position to be proven to accomplish the specified control sequence.
5. Coordinate installation with the sheetmetal installer to obtain smooth duct transitions where damper size is different than duct size. Blank off plates will not be accepted.
6. Each operator shall serve a maximum damper area of 36 square feet. Where larger dampers are used, provide multiple operators.

C. Control Valves:

1. All temperature control valves furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control.
2. Sizing/selection criteria:

a. Valves with pressure drop greater than 50% of upstream pressure shall have sound reduction trim.
b. Water Service:

1) Characteristic: equal percentage for two-way valves; linear for three-way valves.
2) Select control valves based on pressure drop calculations based on C_v values at 100% stroke.
3) Heating: globe type, selected for a minimum of 25% of equipment subcircuit pressure drop but no more than maximum available pump head allowing 2 psi pressure drop for balancing valve.

D. Air Temperature Sensors:

1. Ducts with cross-sectional area less than 3 square feet: single point type.
2. Ducts with cross-sectional area more than 3 square feet: RTD type.
3. Mixed air: averaging type

3.3 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

1. Check and verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Align with light switches and humidistats. For drywall installations, thermostat mounting shall use a back-box attached to a wall stud, drywall anchors are not acceptable.

C. Verify location of thermostats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
2. Meet ADA requirements.
3. Locate temperature sensors away from direct sunlight, diffuser air streams, and heat sources.
4. Install thermostats and temperature sensors mounted on outside walls on insulated subbases. Subbase to provide a minimum of one-half inch of insulation.
5. Install devices with visible readouts where the display can be easily read.

D. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.
4. Provide guards on thermostats and sensors in entrance hallways, other public areas, or in locations where thermostat is subject to physical damage.

E. Install automatic dampers according to Section 23 33 00 "Air Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Section 23 05 53 "Identification for HVAC Piping and Equipment."

H. Install hydronic instrument wells, valves, and other accessories according to Section 23 21 16 Hydronic Piping Specialties."

I. Install electronic and fiber-optic cables according to Division 27.

J. Provide power wiring to each component requiring power, such as control panels. Use circuits dedicated for controls. For equipment on emergency power, use emergency power circuits for their controllers.

K. Mount all control devices in accessible locations.

L. Interposing Relays:

1. Provide interposing relays necessary for interfacing to low voltage outputs with 120 VAC or line voltage motor control.

   a. Use Type C horsepower rated interposing relays for motors and electric heaters.
   b. Use Type K interposing relays for other general-purpose use.

M. Well-Mounted Sensors:

1. Install thermal conducting compound.
2. In pipe 2½ inches and smaller: install at elbow with tee fitting with well pointed upstream. Minimum 2” tee size.
3. In pipe 3 inches and larger: install the element in the flow.

N. Low Limit Thermostats (Freezestats):

1. Install low limit controls where indicated on the drawings or as specified. Unless otherwise indicated, install sensing element on the downstream side of heating coils.
2. Mount units using flanges and element holders. Provide duct collars or bushings where sensing capillary passes through sheetmetal housings or ductwork; seal this penetration to eliminate air leakage. Mount the units in an accessible location as to allow for resetting after low limit trips while still meeting manufacturer's installation requirements for proper function.
3. Distribute (serpentine) sensing element horizontally across the coil to cover every square foot of coil; on larger coils this may require more than one instrument. Install controls at accessible location with mounting brackets and element duct collars where required.

O. Air Flow Stations:

1. Install airflow stations in accordance with manufacturer's recommendations.

P. Temperature Control Panels:

1. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. All control panel openings shall be plugged. Conduits and other penetrations on the top of the cabinets shall be sealed on the exterior of the cabinet with silicone caulk to resist water penetration. One cabinet may accommodate more than one system in same equipment room. Provide permanent printed labeling for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
2. Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings

Q. Current Status Switches:

1. Provide for each fan or pump specified or shown on point list. Set threshold adjustment to indicate belt or coupling loss. Readjust threshold for proper operation after final balancing is completed. Use the variable frequency drive (VFD) integrated relay output for motor status, if provided on the VFD, in lieu of a discrete current switch.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 26 05 33 "Raceways and Boxes for Electrical Systems."

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

    a. Republic Conduit.
    b. Southwire Company.
    c. Western Tube and Conduit Corporation.
    d. Wheatland Tube Company.

3. RMC: Comply with ANSI C80.1 and UL 6. Hot-dip galvanized rigid metal conduit system.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Fittings for EMT:

    a. Material: Steel.
    b. Type: Setscrew.

5. Expansion Fittings: Steel to match conduit type, complying with type XJ for steel, rated for environmental conditions where installed, and including flexible external bonding jumper.
6. Joint Compound for RMC Approved, as defined in NFPA, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

C. Install building wire and cable according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Install signal and communication cable for communications horizontal cabling.

1. All cabling to be installed in RMC raceway.
2. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
4. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
5. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Route wires parallel or perpendicular to the building structural elements.
7. Do not route wires across telephone equipment areas.
8. In enclosures, install wiring in plastic track.
9. In controllers, wrap and secure all wiring.
10. Install wires at least 3 inches away from hot surfaces, such as steam and hot water pipes.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

G. Where the sensor voltage exceeds the controller's allowed input voltage, modify the circuit with resistor(s) so that the input voltage to the controller is as high as practical and below the controller's limit.

H. Provide transient voltage surge protection according to Division 26.

I. For equipment powered by standby emergency power, provide power to the equipment's controller from a standby power panel.

3.5 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. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

    a. Use manufacturer's linearity curve to lineraize the signal from each sensor.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at

least double that of instrument being calibrated. Factory calibration does not replace field calibration.

4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Section 01 79 00 "Demonstration and Training."

1. The first training session, minimum 8 hours, shall take place just prior to Substantial Completion. Training shall include system operation, maintenance procedures, and operating the system software. Submit O&M manuals at least one week prior to training session.
2. A follow-up training session, minimum 4 hours, shall take place approximately six months after Substantial Completion to assist troubleshooting answer questions.
3. A second follow-up training session, minimum 4 hours, shall take place approximately twelve months after Substantial Completion (just before the end of the warrantee period) to assist troubleshooting answer questions.

END OF SECTION 23 09 00

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SECTION 23 09 24
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SCOPE

A. The work associated with this section will be bid as part of the Division 23 scope of work.

B. Work in this section includes Direct Digital Control (DDC) panels, main communication trunk, software programming, and other equipment and accessories necessary to constitute a completely coordinated building Direct Digital Control (DDC) system. This system interfaced with Instrumentation and Controls for HVAC (Section 23 09 00) utilizing Direct Digital Control signals to operate actuated control devices will meet, in every respect, all operational and quality standards specified herein, a fully coordinated modification and extension via standard Web browser-IP address DDC of the City of Madison's Automation System.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASCs, and operator devices.

D. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

1.2 RELATED WORK

A. Section 23 08 00 "Commissioning of HVAC."

B. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

C. Section 23 09 00 "Instrumentation and Controls for HVAC."

D. Division 22 plumbing equipment provided to be controlled or monitored

E. Division 23 HVAC equipment provided to be controlled or monitored.

1.3 REFERENCE

A. Applicable provisions of Division 1 govern work under this section.

1.4 REFERENCE STANDARDS

A. FCC Part 15, Subpart J, Class A - Digital Electronic Equipment to Radio Communication Interference.

1.5 WORK NOT INCLUDED

A. Section 23 09 00 work includes furnishing and installing all field devices, including electronic sensors for the DDC of this section, equipment, and all related field wiring,

interlocking control wiring between equipment, pneumatic tubing, sensor mounting, etc., that is covered in that section.

B. Motorized control dampers and actuators, thermowells (temperature sensing wells), automatic control valves and their actuators are also covered in Section 23 09 00.

1.6 DESCRIPTION

A. The DDC control work associated with this section shall be bid as part of the Temperature Control Contract scope of the Work.

B. The Building Automation System (BAS) shall be an based on a hierarchical architecture incorporating the Niagara AX Framework™ using Honeywell WEBs-AX™. All Building Management Functions shall be operable from the existing Honeywell workstations.

C. The BAS shall consist of the following:

1. AX Supervisor Lon Web Connection.
2. Building Operator's AX Supervisor Web Station.
3. WEBs-AX™ - Direct Digital Control Panels.
4. WEBs-AX™ 600 - Master Controls
5. Spyder Controllers Standalone Application Specific Controllers (ACSs).
6. LonWorks Network Wiring
7. City of Madison Lan/Wan Integration

1.7 OPEN COMMUNICATION

A. Industry standard Open Communication Protocols shall be provided as specified in the applicable communication sections.

B. LonWorks® compliance:

1. The fully integrated Honeywell WEBs-AX™ System shall be operable on the LonWorks® bus. General Purpose Controllers, Unitary Controllers, and PC-based centrals shall be able to operate and communicate on the 2-wire LonWorks® bus without the need of using gateways or drivers.
2. The Systems Integrator shall after all hardware (devices/nodes and wiring) has been installed provide all necessary device installation, device configuration, device diagnostics, network variable binding and systems diagnostics.
3. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each network controller shall communicate to LonMark™/LonTalk™ (IDC) and/or BACnet™ (IBC) controllers.

1.8 QUALITY ASSURANCE

A. Manufacturers:

1. Control Works Inc.

    a. E-mail marquis@charter.net

b. P.O. 7066
c. Madison, WI 53706
d. 608-347-6108

B. Installer Qualifications:

1. A firm specializing and experienced in DDC control system installation with a local service office within 60 miles of Madison and experience with similar installations for no less than five (5) years. All work to be done by qualified mechanics in the direct employ of this manufacturer.
2. All engineering and commissioning work shall be done by qualified personnel in the direct employ of this manufacturer, or of an Authorized Representative of that manufacturer that provides engineering and commissioning of the manufacturers control equipment.
3. Where installing contractor is an authorized representative of the control equipment manufacturer, submit written confirmation of such authorization. Indicate in letter of authorization that the installing contractor has successfully completed all necessary training required for the engineering, installation, and commissioning of equipment and systems to be provided for the project, and that such authorization has been in effect for a period of not less than three (3) years.

C. Response Time:

1. During warrantee period, four (4) hours or less, 24-hours/day, 7 days/week.

D. Authorized Controls Integrator:

1. The control contractor shall be a Honeywell ACI – Authorized Integrator.

E. Electrical Standards:

1. Provide electrical products, which have been tested, listed and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards.
2. DDC Standards: DDC manufacturer shall provide written proof with shop drawings that the equipment being provided is in compliance with FCC rules governing the control of interference caused by Digital Electronic Equipment to Radio Communications (Part 15, Subpart J, Class A).

1.9 SUBMITTALS

A. Include the following information:

1. Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Indicate which piece of mechanical equipment is associated with each controller and what area within the building is being served by that equipment. For terminal unit control, provide a room schedule that lists mechanical equipment tag, room number of space served, address of DDC controller, and any other pertinent information required for service.

1.10 PRODUCT DATA

A. Submit manufacturer's specifications for each control device furnished, including installation instructions and startup instructions. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked. Annotated software program documentation shall be submitted for system sequences, along with descriptive narratives of the sequence of operation of the entire system involved. Shop drawings shall also contain complete software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Submit wiring diagram for each electrical control device along with other details required to demonstrate that the system has been coordinated and will function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

B. All control devices in public areas shall be selected by Architect from one of the manufacturer's standard colors.

C. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or City's representative.

1.11 MAINTENANCE DATA

A. Submit maintenance data and spare parts lists for each control device. Include this data in maintenance manual.

1.12 RECORD DRAWINGS

A. Prior to request for final payment provide complete composite record drawings to incorporate the DDC and Electric fieldwork. Provide application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Copies of the record drawings shall be provided in addition to the documents on compact disk. All record drawings shall also be installed into the BAS server in a dedicated directory. Accurate Section 23 09 00 record drawings to be supplied by the Section 23 09 00 Contractor with the accuracy of these drawings being the responsibility of the 23 09 00 contractor. In the event that changes are required to the 23 09 00 supplied record drawings after they have been compiled by the 23 09 24 contractor, it shall be the 23 09 00 contractors responsibility to provide updated composite record drawings incorporating the 23 09 24 record drawings.

B. All software addressing for device communication shall be noted for all devices provided under this section and the communication addressing required for devices provided by others that are integrated into the direct digital control system provided under this section. Coordinate with the supplier of the equipment specified to be interfaced through digital communications for communication addressing. Provide circuit number of 120VAC panel power circuit(s) feeding each control panel on record drawings. Label circuit number(s) inside the panel served.

C. Prior to request for final payment, provide complete composite record drawings to incorporate the DDC and Electric fieldwork.

1.13 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.14 MATERIAL DELIVERY AND STORAGE

A. Provide factory-shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

PART 2 - PRODUCTS

2.1 NETWORKING/COMMUNICATIONS

A. The design of the BAS shall be networked as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via a local network or a standard Web browser. A combination of the two networking schemes.

B. City to provide network connections for the network Honeywell JACE 600 controllers.

C. Local Network:

1. Building DDC Panel Support:

    a. The Digital Panel shall directly oversee a local network such that communications may be executed directly to and between ASCs. The Digital Panel version shall be referred to as the "Digital Panel(s)" throughout this document.

D. Data Access:

1. All operator devices either network resident or a standard Web browser, shall have the ability to access all point status and application data on the network.
2. Access to system data shall not be restricted by the hardware configuration of the BAS.
3. All operators shall have the ability to collect data for any property of any object and store this data for future use.
4. The data collection shall be performed by log objects, resident in the controller that shall have, at a minimum, the following configurable properties:

    a. Designating the log as interval or deviation.
    b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.

c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

E. All log data shall be stored in a relational database in the controller and the data shall be accessed from a server (if the system is so configured) or a standard Web browser. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

F. All log data shall be available to the user in the following data formats:

1. HTML (deal breaker).
2. XML (deal breaker).
3. Plain Text.
4. Comma or tab separated values.
5. PDF.

G. All operators shall have the ability to archive its log data either locally (to itself), or remotely to a server or other controllers on the network. Provide the ability to configure the following archiving properties, at a minimum:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

H. Measured and calculated analog and binary data shall be assignable to user definable trends for the purpose of collecting operator specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one minute or one hour intervals, shall be provided. Each supervisory controller shall have a dedicated buffer for trend data and shall be capable of storing 16 trend logs. Each trend log shall have up to four points trended at 48 data samples each. Data shall be stored at the supervisory controller and up-loaded to the DDC system server when archiving is desired.

I. Supervisory controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis, user defined, for user-selected analog and binary pulse input type points.

1. Totalization shall provide calculation and storage accumulations of up to 9,999,999 units (e.g., KWH, gallons KBTU, tons, etc.).
2. The totalization routine shall have a sampling resolution of one minute.
3. The user shall have the ability to define a warning limit. Unique, user specified messages shall be generated when the limit is reached.
4. The information available from pulse totalization shall include, but not be limited to, the following:

a. Peak demand, with date and time stamp.
b. 24-hour demand log.
c. Accumulated KWH and therms for day.
d. Sunday through Saturday KWH and therm usage.
e. Demand KW annual history for past 12 periods.
f. KWH and therm annual history for past periods.

J. Supervisory controllers shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off.

K. The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

L. Global Data Sharing: global Data Sharing or Global point broadcasting shall allow point data to be shared between ASCs, when it would be inefficient or impractical to locate multiple sensors.

M. General Network Design: Network design shall include the following provisions:

N. Data transfer rates for alarm reporting and quick point status from multiple ASCs. The minimum baud rate shall be 9600 baud.

O. Support of any combination of ASCs. A minimum of 100 ASCs shall be supported on a single local network. The bus shall be addressable for up to 255 ASCs.

P. Detection of single or multiple failures of the ASCs or the network media.

Q. Error detection, correction, and retransmission to guarantee data integrity.

R. Commonly available, multiple sourced, networking components shall be used.

S. Use of an industry standard protocol, such as Optomux, and IEEE RS-485 communications interface.

T. The HVAC BAS provided under this section of the specifications shall consist of a distributed Client-Server, Local Area Network (LAN) based system, a dedicated local area network, routers, switchers, network nodes, direct digital control system and software to provide interoperability with the server software. The system is to be furnished and installed in its entirety by this supplier.

U. The HVAC BAS shall be modular in design and scaleable in implementation from an initial installation of a single server with minimum of two concurrent operator workstations to a system with up to 40 concurrent operator workstations, unlimited web browser access (using Internet Explorer) to system information for monitoring and control functions, and field controller network interfaces to permit expansion to 60,000 physical hardware points.

2.2 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™ or Firefox.

Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS, shall not be acceptable.

C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface (if used). Systems that require different graphic views, different means of graphic generation, or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

D. The Web browser client shall support at a minimum, the following functions:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

    a. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
    b. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

2. Storage of the graphical screens shall be in the All operators/controllers, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
3. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
4. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

    a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
    b. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    c. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    d. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No text entry shall be required.
    e. View logs and charts.
    f. View and acknowledge alarms.
    g. Setup and execute SQL queries on log and archive information.

5. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to set a specific home page for each user. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
6. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.3 DIGITAL PANELS

A. General: Digital Panels shall be microprocessor-based, multi-tasking, multi-user, digital control processors.

B. Memory: Each Digital Panel shall have sufficient memory to support its own operating system and databases including:

1. Control Processes.
2. Energy Management Applications.
3. Alarm Management.
4. Trend Data.
5. Maintenance Support Applications.
6. Operator I/O.
7. Dial-Up Communications.
8. Manual Override Monitoring.

C. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of field controllers, sensors, and actuators.

D. Serial Communication Ports: Digital Panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as laptop computers, Personal Computers, and Video Display terminals.

E. Hardware Override Monitoring: Digital Panels shall monitor the status of al overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

F. Integrated On-Line Diagnostics: Each Digital Panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The Digital Panels shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each Digital Panel.

G. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

H. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of the Digital Panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller

configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

I. Upon restoration of normal power, the Digital Panels shall automatically resume full operation without manual intervention.

2.4 SYSTEM SOFTWARE FEATURES

A. General:

1. All necessary software to form a complete operating system as described in this specification shall be provided.
2. The software programs specified in this section shall be provided as an integral part of the Digital Panel and shall not be dependent upon any higher level computer for execution.

B. Graphic Requirements: Provide color graphic backgrounds with operational information interface for the following systems:

1. Hot water hydronic system with unit heaters.
2. Make-up Air system with MAU-1.
3. Make-up Air system with MAU-2 .
4. Energy Recovery Unit ERV-1 with Duct Furance DF-1.
5. Energy Reovery Unit ERV-2 with Duct Furance DF-2.
6. Exhaust Fans.
7. Fume Extractors FE-1/FE-2
8. Ductless Splits
9. Sump Pump
10. Domestic Water Heaters
11. Building Floor Plan graphic for temperature sensor information and terminal unit service designations.

C. Control Software Description:

1. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
2. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
3. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

D. Energy Management Applications: Digital Panels shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling.
2. Calendar Based Scheduling.
3. Holiday Scheduling.

4. Temporary Schedule Overrides.
5. Optimal Start.
6. Optimal Stop.
7. Demand Limiting.
8. Load Rolling.
9. Heating/Cooling Interlock.
10. Average/High/Low Signal Select and Reset.

E. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the “Execution” portion of this specification.

F. Programming Capability: Digital Panels shall be able to execute configured processes defined by the user, to automatically perform calculations and control routines.

G. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

1. Any system-measured point data or status.
2. Any calculated data.
3. Any results from other processes.
4. Boolean logic operators (and, or,).

H. Process Triggers: Configured processes may be triggered based on any combination of the following:

1. Time of Day.
2. Calendar Date.
3. Other Processes.
4. Events (e.g., point alarms).

I. Data Access: A single process shall be able to incorporate measured or calculated data from any and all other ASCs.

1. In addition, a single process shall be able to issue commands to points in any and all other NCUs on ASCs local network.

J. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each Digital Panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the Digital Panel’s ability to report alarms be affected by either operator activity at the local I/O device, or communications with other ASCs on the network.

K. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to more fully describe the alarm condition or direct operator response.

L. Each Digital Panel shall be capable of storing a library of at least 100 Alarm Messages. Each message may be assignable to any number of points in the panel.

M. Auto-Dial Alarm Management: In dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

N. Trend Analysis: A data collection utility shall be provided to automatically sample, store and display system data.

O. Measured and calculated analog and binary data shall be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one-minute or one-hour intervals, shall be provided. Each Digital Panel shall have a dedicated buffer for trend data, and shall be capable of storing 32 trend logs. Each trend log shall have up to 4 points trended at 268 data samples each. data shall be stored at the Digital Panel.

P. Runtime Totalization: Digital Panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the “Execution” portion of this specification.

1. The Totalization routine shall have a sampling resolution of one minute.
2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

Q. Event Totalization: Digital Panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.5 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each Digital Panel shall be able to extend its performance and capacity through the use of standalone Application Specific Controllers (ASCs).

B. Each ASC shall operate as a standalone controller capable of performing its specific control responsibilities independently of other controllers in the network. Each ASC shall be of microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases including:

1. Control Processes.
2. Energy Management Applications.
3. Operator I/O (Portable Service Terminal).

D. The operator interface to any ASC point data or programs shall be through the Digital Panel or portable operator's terminal connected to any ASC on the network.

E. ASCs shall directly support the temporary use of a portable service terminal that can be connected to the ASC via zone temperature or directly at the controller. The capabilities of the portable service terminal shall include, but not be limited to, the following:

1. Display temperatures.
2. Display status.
3. Display setpoints.
4. Display control parameters.
5. Override binary output control.
6. Override analog setpoints.
7. Modification of gain and offset constants.

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

2.6 APPLICATION DESCRIPTIONS

A. Unitary Controllers:

B. Unitary Controllers shall support, but not be limited to, the following types of systems to address specific applications described in the “Execution” portion of this specification, and for future expansion:

1. Ductless Split Systems.
2. Generic Point Multiplexing.

C. Unitary Controllers shall support the following types of point inputs and outputs:

1. Economizer Switchover Inputs:

    a. Drybulb.
    b. Outdoor Air Enthalpy.
    c. Differential Temperature.
    d. Binary Input from a separate controller.

2. Economizer Outputs:

    a. Integrated Analog with minimum position.
    b. Binary Output to enable self-containe.
    c. Economizer Actuator.

3. Heating and Cooling Outputs:

    a. 1 to 3 Stages.
    b. Analog Output with two-pipe logic.
    c. Reversing valve logic for Heat Pumps.

4. Fan Output:

    a. On/Off Logic Control.

D. Unitary controllers shall support the following library of control strategies to address the requirements of the sequences described in the “Execution” portion of this specification, and for future expansion:

1. Daily Schedules.
2. Comfort/Occupancy Mode.
3. Economy Mode:

    a. Standby Mode/Economizer Available.
    b. Unoccupied/Economizer Not Available.
    c. Shutdown.

4. Lighting Logic Interlock to Economy Mode.
5. Temporary Override Mode:

    a. Temporary Comfort Mode (Occupancy-Based Control)
    b. Boost (Occupant Warmer/Cooler Control)

E. MAU Controllers:

1. MAU Controllers shall support, but not be limited to the following configurations of systems to address current requirements as described in the “Execution” portion of this specification, and for future expansion:

    a. Make-up Air Units:

        1) 100% Single Path.
        2) Generic Point Multiplexing.

F. MAU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

G. MAU controllers shall have a library of control routines and program logic to perform the sequence of operation as specified in the “Execution” portion of this specification.

H. Continuous Zone Temperature Histories: Each MAU Controller shall automatically and continuously, maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

I. Alarm Management: Each MAU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

J. Each MAU Controller shall come with a hand-held Zone Terminal permanently mounted at the controller to allow interface with the controller. This device will allow the user to monitor or adjust set points and time scheduling within a specific zone.

2.7 OPERATOR INTERFACE

A. Basic Interface Description.

B. Command Entry/Menu Selection Process: Operator interface software shall minimize operator training through the use of English language prompting, English language point identification.

C. The operator interface shall have the option of using a mouse or similar pointing device for a “point and click" approach to facilities management. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

D. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit control, display and database manipulation capabilities as he deems appropriate for each user, based upon an assigned password. Provide secure password access to all features, functions and data contained in the overall BAS.

E. Passwords shall be exactly the same for all operator devices.

F. A minimum of four (4) levels of access shall be supported:

1. Level 1 = Data Access and Display.
2. Level 2 = Level 1 + Opera.tor Overrides and Commands.
3. Level 3 = Level 2 + Operator Management.
4. Level 4 = Level 3 + Database Generation and Modification.

G. A minimum of eight (8) passwords shall be supported at each Digital Panel.

H. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, shall be limited to only those items defined for the access level of the password used to log-on.

I. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices logged on.

J. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

1. Start-up or shutdown selected equipment.
2. Adjust setpoints.
3. Add/Modify/Delete time programming.
4. Enable/Disable process execution.
5. Lock/Unlock alarm reporting for each point.
6. Enable/Disable Totalization for each point.
7. Enable/Disable Trending.
8. Enter temporary override schedules.
9. Define Holiday Schedules.
10. Change time/date.
11. Enter/Modify analog alarm limits.
12. Enable/Disable demand limiting.
13. Enable/Disable duty cycle.
14. Enable/Disable average/high/low signal select and reset.

K. Logs and Summaries: Reports shall be generated manually, and directed to the displays. As a minimum, the system shall allow the user to easily obtain the following types of reports:

L. A general listing of all points in the network shall include, but not be limited to, the following:

1. Points currently in alarm.
2. Off-line points.
3. Points currently in override status.
4. Points in Weekly Schedules.
5. Holiday Programming.

M. Summaries shall be provide for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

N. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

O. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

1. Add/Delete/Modify Application Specific Controllers.
2. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants.
3. Add/Delete/Modify alarm reporting definition for each point.
4. Add/Delete/Modify energy management applications.
5. Add/Delete/Modify time- and calendar-based programming.
6. Add/Delete/Modify Totalization for every point.
7. Add/Delete/Modify Historical Data Trending for every point.
8. Add/Delete/Modify configured control processes.
9. Add/Delete/Modify dial-up telecommunication definition.
10. Add/Delete/Modify all operator passwords.
11. Add/Delete/Modify Alarm Messages.

P. Programming Description: Definition of operator device characteristics, ASCs, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.

Q. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data.

R. Database Save/Restore/Back-Up: Back-up copies of all ASC and Digital Panel databases shall be stored in at least one personal computer or laptop. Users shall also have the ability to manually execute downloads of an ASC or Digital Panel data base.

S. Interface with City of Madison Central BAS System: Provide a standard Web browser with IP address for connection to existing City Central BAS System. Update graphics on City Central BAS System as required to allow central monitoring of this project control system.

T. Graphical User Interface Computer Hardware (Desktop):

1. Contractor shall provide 2 network ports in or near mechanical room. Exact location to be provided by owner on site. Coordinate with Owner's Representative on interface with their computer hardware desktop.

PART 3 - EXECUTION

3.1 GENERAL

A. This contractor shall provide all labor, materials, engineering, software permits, tools, check-out and certificates required to install a complete DDC automation system as herein specified. This system expansion shall be compatible with and interfaced to the existing computer driven automation center on campus, and shall operate through all the existing I/O devices, central processing unit (CPU), and digital communication trunks. This connection to the digital communications trunk shall be true bi-directional analog and digital communications.

B. Any and all points added with this project shall be properly interfaced into the existing City's existing central automation system via standard Web browser-IP address format and grouped for display purposes into the system such that all points associated with a new or existing DDC system can appear together on the CRT display or printed log. Assignment of points to a group shall not be restricted by hardware configuration of the points of direct digital control. It shall be possible to assign a point to appear in more than one system. An English descriptor and an alpha/numeric identifier shall identify each system.

C. This City's central automation system expansion as herein specified shall be fully integrated and completely installed by this section. It shall include all required computer CPU software and hardware. Include the engineering, installation, supervision, calibration, software programming, and checkout necessary for a fully operational system.

D. Mechancial drawings of the system and BAS network are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the Engineer shall be furnished and installed without additional cost.

3.2 INSTALLATION

A. Install the control system in accordance with manufacturer's instructions.

B. All work and materials are to conform in every detail to the rules and requirements of the National Electrical Code and any applicable local codes, and present manufacturing standards. All wiring and cable installation shall conform with the wiring installation as

specified in the installation section of Section 23 09 00. All material shall be UL approved.

C. The addition of this specified system expansion shall in no way impair the future capabilities of any existing functions of the computer driven existing City central campus automation system. A system expansion with lessor capabilities will not be accepted. Further, this contractor will not put in jeopardy the normal, uniterruptable operation of the entire campus automation system the time it is interfaced through the completion of this project.

D. Install system and materials in accordance with manufacturer's instructions, rough-in drawings and details on drawings.

E. Line voltage wiring to power the DDC Controllers, not provided by the Division 26 contractor, to be by this contractor.

F. Control panels shall not be installed in concealed areas. All panels shall be accessible and serviceable which will provide minimal disruption to the building occupant or function. Consult with maintenance operation staff for recommended locations. Final location shall be decided by the Owner’s Project Represenative.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide printed plastic tags for instruments and controls inside cabinet and on engraved plastic nameplates cabinet face.

H. Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

I. Provide an input for a service shutdown toggle switch for each make-up air unit system provided inside the (Section 23 09 00) temperature control panel that will initiate a logical shutdown of the make-up air unit system.

J. All cables to the DDC panels in the DDC panel with sufficient spare cable (minimum of 5') to allow termination.

3.3 ACCEPTANCE TESTING

A. Upon completion of the installation, this contractor shall load all system software and start-up the system. This contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.

B. This contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log. Schedule with the Commissioning Agent, CxP, that allows in advance notice of 5 business days of the testing so that the CxP may

witness as deemed necessary. Also notify the Owner's Representative, as required. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

D. System Acceptance: Satisfactory completion is when all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the CxP, Engineer, and Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.4 DEMONSTRATION

A. The system manufacturer or his representative shall provide start-up and adjustment service for the control system.

B. The system manufacturer or his representative shall provide a minimum eight (24) hours of training for the Owner's personnel on the operation and maintenance of the packaged control system.

3.5 TRAINING

A. All training provided for personnel shall comply with the format, general content requirements and submission guidelines specified under Section 01 79 00.

B. Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 8 hours for total of 24 hours.

C. Contractor to provide 24 hours of instruction training to the owner's designated personnel on the operation of the the system and describe its intended use with respect to the programmed functions specified. Operator orientation of the systems shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part tof the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.

D. The instructional training shall be in two sessions as follows:

1. Initial Instructional Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the owners' personnel can start to familiarize themselves with the system before classroom instruction begins.
2. First Follow-Up Instructional Training: Two days (16 hours total) approximately two weeks after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics such as data collection, event counting and answer questions.

E. Provide two follow-up visits for troubleshooting and instruction, one six months after substantial completion and the other at the end of the warranty period. Length of each visit to be not less than 2 hours or the time necessary to provide required information and complete troubleshooting and inspection activity for all controls installed under this

section. Coordinate the visit with the City and provide an inspection report to the Owner's representative of any deficiencies found.

3.6 COMMISSIONING

A. The contractor shall provide web access via Web browser-IP address to the Commissioning Agent and/or Engineer to enable access to and from the server.

END OF SECTION 23 09 24

SECTION 23 09 93
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

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 control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:

1. Section 23 09 00 "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. BAS: Building Automation System

C. VAV: Variable air volume.

D. Inches w.g.: Inches of water gauge, or inches of water column.

1.4 GENERAL

A. A value in this specification followed by the word “adjustable” means the value can be changed manually through the DDC system by the Owner.

B. All duct mounted smoke detectors shall be provided and installed by this contractor. 120/1 electrical power to the detectors will be provided by the Electrical Contractor. ALL other required wiring to achieve a complete and fully functioning duct smoke detection system that is California code and NFPA standard compliant as well as acceptable to the local authority having jurisdiction. Wire all duct smoke detectors to a single remote alarm horn and trouble annunciator alarm wall mounted in a normally occupied area. Verify alarm horn and trouble annunciator location with Owner.

C. The DDC control systems shall be connected to the main fire suppression control panel. When this fire suppression system is activated, the fire suppression system shall shut down ALL equipment fan motors via the DDC temperature system. This contractor shall provide all materials and labor required for this control feature. The fire suppression system panel and its programming shall be by others.

D. All control points shall be exposed as BACnet objects and shall be viewable and editable over the internet from a remote location with a standard web browser.

E. For pushbutton switches mentioned in the sections below, provide the Owner with a sample of each type used for approval prior to installation.

F. When filter pressure monitoring and control is required for a unit, filter monitoring and control shall apply to all filter banks in the unit.

G. Setpoints:

1. All setpoints indicated in the control specification are to be adjustable. The setpoints shall be readily available to be modified in the mechanical system software system summary (either textual or graphic based) and under the same software level as hardware points. Some less used setpoints may be provided on a lower software level, if requested by the Owner for clarity. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on requirements of the building. The control contractor shall work with the balancing contractor and the Owner to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use. Document all final setpoints on the as-built control drawings. Any questions regarding the intended operation of the HVAC equipment and control systems shall be referred to the HVAC design engineer through the appropriate construction communication process. The following setpoints should be used as initial setpoints unless otherwise specified in the individual control sequences or instructed by the user Agency. If the contractor fails to check with the user Owner for final setpoints, they shall adjust setpoints at no additional cost.

a. Occupied Space Terminal Unit Heating: 68 deg F
b. Occupied Space Terminal Unit Cooling: 75 deg F
c. Unoccupied Space Terminal Unit Heating: 60 deg F
d. Unoccupied Space Terminal Unit Cooling: 80 deg F

H. Anti-cycling:

1. When HVAC equipment or a sequence is specified to be started and stopped by a temperature, pressure setpoint or any other controlled variable, there shall be an adjustable differential setpoint that shall be set to prevent short cycling of the systems and equipment due to minor changes in the controlled variable. Temperature differential setpoints shall be set at 2 deg F and non-temperature setpoints shall be set at 10% of the controlled range unless otherwise specified. Setpoints shall indicate at when the process should be turned on. Heating and cooling differentials shall be set for above setpoint and shall be used to turn the process off. For example, an economizer sequence called to switch at 68º F, would turn on at 68 deg F and off at 70 deg F since it is a cooling function. A heating lockout setpoint of 50º F would turn on heating control at 50 deg F and off at 52 deg F Non-temperature differentials shall be set above setpoint if the setpoint is indicating a minimum value or below setpoint if the setpoint is indicating a maximum value. Provide minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans shall have a minimum runtime on timers

of 15 minutes (adj.) and off timers of 5 minutes (adj.). Safeties shall override runtime timers.

I. Deadbands:

1. Provide deadbands for all DDC control loops to prevent constant hunting of output signals to controlled devices. Deadbands shall be set to provide adequate control around setpoint as follows unless otherwise specified in the individual control sequences:

   a. Temperature Control: ±0.5 deg F
   b. Humidity Control: NA
   c. Airflow Control: ±2% of total flow
   d. AHU Static Pressure Control: ±0.01 in. w.c.

J. Alarms:

1. Provide all alarmed points with adjustable time delays to prevent nuisance tripping under normal operation and on equipment start-up. For all commanded outputs that have status feedback, provide an alarm that shall indicate the commanded output is not in its commanded state. Provide alarms on all points as indicated on point charts. For existing campus automations systems, add/delete what is called on the point charts for after consultation with user Agency to provide consistent alarming throughout the automation system.

2. For devices that have form “C” contacts available for alarm monitoring, use closed contacts for the Normal condition and open contacts on Alarm condition. This shall provide a level of supervision by detecting a break in the wiring.

K. Equipment Start/Stop Failure States:

1. All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

L. Variable Frequency Drive (VFD) Motor Run Status:

1. Use the VFD programmable relay dry contact output specified to be provided with the VFD under Section 23 05 14 to prove motor run status and detect belt loss or coupling break.

M. VFD Minimum Speed & Ramp Timers:

1. The VFD start-up technician shall work with the DDC Temperature Control Contractor determine the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP.

N. Current Switch Setup:

1. When current switches are used for proving fan status, they shall be set up so that they will detect belt or coupling loss by the reduction in current draw on loss of coupled load. The current switch set up shall be redone by the 23 09 00 contractor after the balancer is complete.

O. Damper Interlocks for Fans with ECM motors:

1. For fan systems with ECM motors and shutoff dampers specified with end switches, the damper interlock shall be hardwired in such a way that the damper shall open if the fan starter hand / off / auto switch is in the hand or in the auto position and being called to start. After the damper end switch has proven the damper open, a hardwire interlock from the end switch to the starter holding coil for the fan shall cause the fan to start.

P. Damper Interlocks for Fans with VFD's:

1. For fan systems with VFD's and shutoff dampers specified with end switches, the damper end switches shall be hardwire interlocked to the safety circuit(s) of the VFD to prevent the fan from starting until the damper is proven open. The damper end switch shall also be monitored by the DDC system.

Q. Fan Interlocking:

1. Provide interlocks between supply and return or exhaust fan systems as scheduled on the plans or called out in individual control sequences. If DDC controlled, interlocks shall be done through DDC start/stop points unless otherwise specified in individual control sequences. If not DDC controlled, interlocks shall be accomplished via hardwire interlocks between fan starters or VFD's.

R. Thermostats and Sensors:

1. All devices and equipment including terminal units, specified to be controlled in a control sequence by a thermostat or sensor, shall be provided with a thermostat or sensor, whether or not the device is indicated on the plans.

S. Watch Dog Timer:

1. Where the integrated system consists of programmable DDC controllers with BACnet objects mapped to an enterprise level Building Automation System (BAS) and it is shown that the BACnet objects do not indicate when they are offline on the enterprise level BAS when communication is lost between the two systems, software algorithms shall be provided to alarm when communication is lost. The integrated system shall program a binary data object that is toggled on and off at an adjustable rate (initially one minute) that shall be monitored by the enterprise level BAS which shall alarm if the toggling ceases.

T. Weekly Scheduling:

1. Provide scheduling of DDC terminal units based on occupancy. Work with the user Owner to determine scheduling and which zones should be included. Individual terminal units shall be able to receive temporary schedules that shall override the group schedules. Temporary override buttons at the zone sensor (where specified on point charts) shall override the scheduling to occupied. When 20 % or more terminal units are indexed to occupied, the associated air handling unit shall start if not already running.

U. DDC Controller Communication Bus Configuration:

1. The actively controlled primary mechanical equipment (VFDs, meters, gas detection, destratification fans etc.) DDC controllers shall be configured to be located on the same supervisory controller BACnet MSTP communication trunk unless the supervisory controller capacity prevents it. If this is the case, the primary mechanical equipment DDC controllers shall be separated onto supervisory controllers in such a way that the systems that need to share information for operation and interlocking shall reside on the same supervisory controllers. Other critical building systems that require communication between DDC controllers to operate shall be on the same BACnet MSTP communication trunk. Terminal unit controllers shall be located on a separate BACnet MSTP trunks if necessary to allow for primary equipment to reside on the same BACnet MSTP trunk. If the DDC controllers used for control of primary mechanical equipment and interlocks or point information is required for proper operation as described above do not use BACnet MSTP communication but use Ethernet communication, the DDC controllers shall be connected to the same Ethernet switch. If the controllers cannot be connected to the same switch, hardwired points between controllers shall be used to share information.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONTROLS

A. Refer to Mechanical drawings M-800 Series for Sequence of Operations for HVAC Controls.

END OF SECTION 23 09 93

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SECTION 23 11 23
FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 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.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

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

B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig but not more than 5 psig and is reduced to secondary pressure of more than 0.5 psig but not more than 2 psig.

1. Madison Metro's existing gas pressure within building is 5 psi downstream of the MG&E's service regulator and meter.

1.4 ACTION SUBMITTALS

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

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

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

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

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

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

1.8 PROJECT CONDITIONS

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

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.9 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08.

1.10 NATURAL GAS SERVICE

A. Contact local gas company for shutdown of the existing gas meter. Any cost of gas service shutdown to building, including pressure reducing valves and gas meter. All charges for gas service shutdown including connection from main in street or other location to gas meter shall be paid by this Contractor.

B. Existing gas service, meters, and regulating equipment on inlet side of meters is existing to remain and operated by the Madison & Electric Gas (MG&E) Company.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Pipe and Fittings: See drawing schedule for pipe and fitting material requirements

2.2 PIPING SPECIALTIES

A. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2½ and larger.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. 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 “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:

    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. 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.

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:

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

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Operator: Square head or lug type with tamperproof feature where indicated.

5. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
6. 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:

   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. Operator: Square head or lug type with tamperproof feature where indicated.
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.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2½ and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Basis-of-Design Product: The design is based on the following:

   a. Maxito Company; Series 325-L with line regulator with OPD.

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

   a. Actaris.
   b. American Meter Company.
   c. Eclipse Combustion, Inc.
   d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   e. Invensys.
   f. Richards Industries; Jordan Valve Div.

3. Body and Diaphragm Case: Cast iron or die-cast aluminum.

4. Springs: Zinc-plated steel; interchangeable.
5. Diaphragm Plate: Zinc-plated steel.
6. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
7. Orifice: Aluminum; interchangeable.
8. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
9. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
10. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Overpressure Protection Device: Factory mounted on pressure regulator.
12. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
13. Provide vent protector for regulator vent opening from the outdoor elements and debris.
14. Regulator certified for up to 5 PSI inlet pressure and outlet pressures ranging 7 to 11 inches WC per ANSI Z21.80/CSA 6.22 in 2 PSI and 5 PSI systems.

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

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

3.3 OUTDOOR PIPING INSTALLATION

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

B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

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

D. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 23 05 19 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with the 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 line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Do not conceal natural gas piping in walls, pipe spaces, utility spaces, below grade or floors, and in floor channels, unless indicated on drawings.

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

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

R. 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.

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

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

U. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 23 05 19 "Meters and Gages for HVAC Piping."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 00 “Common Work Results For HVAC."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 00 “Common Work Results For HVAC."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 00 “Common Work Results For HVAC."

3.5 VALVE INSTALLATION

A. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 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.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install restraints on piping. Comply with requirements for restraint devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

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

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1¼: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1½ and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2½ to NPS 3: 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.

D. Provide additional intermediate supports as required so deflection of piping does not exceed 1/240 of span.

E. Support spacings listed above are minimum requirements. Contractor shall provide additional supports as required by codes or authority having jurisdiction at no additional cost to contract.

3.8 CONNECTIONS

A. Connect to gas service in the existing boiler’s gas service.

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.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.10 PAINTING

A. Paint exposed, exterior metal piping, valves, service regulators, 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 (gloss).
d. Color: Gray.

B. Paint exposed, interior metal piping, valves, service regulators, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.

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

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

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the 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.

E. Prior to start-up, Contractor shall verify gas system pressure downstream of gas meter as indicated on plans. If meter pressure is not within ±5% of pressure indicated on plans, Contractor shall notify the Architect/Engineer and Owner immediately.

1. If a pressure tap is not available for connectors of a gas pressure gauge, one shall be installed at no additional cost to the Contract.

F. Downstream gas pressure measurement shall be taken within 15 feet of the gas meter discharge and within the existing boiler room.

3.12 OUTDOOR AND INDOOR PIPING SCHEDULE

A. See pipe and valve schedule on drawings for piping materials schedule.

3.13 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. See pipe and valve schedule on drawings for piping materials schedule.

END OF SECTION 23 11 23

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SECTION 23 21 13
HYDRONIC 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 ACTION SUBMITTALS

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

1. Chemical treatment.

1.3 INFORMATIONAL SUBMITTALS

A. None.

1.4 QUALITY ASSURANCE

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

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

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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. Condensate-Drain Piping: 150 deg F.
3. Air-Vent Piping: 200 deg F.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

1. Basis-of-Design Product: The design is based on the following:

    a. Victaulic Company.

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

    a. Anvil International, Inc.
    b. Star Pipe Products.

3. Mechanical grooved pipe couplings and fittings may be used with steel pipe on the systems indicated below. Either cut-groove or equivalent roll-groove products are acceptable providing the system temperature and pressure requirements are met. Where malleable iron fittings are indicated, they shall conform to ASTM A47. Where ductile iron fittings are indicated, they shall conform to ASTM A 536. Where forged steel fittings are indicated, they shall conform to ASTM A106, Grade B. Where fabricated steel fittings are indicated, they shall conform to ASTM A53, type F in sizes ¾" through 1½" and type E or S, grade B in sizes 2" through 20". Do not use fabricated fittings where malleable or ductile iron or

forged steel fittings are available. Gaskets in all cases shall be EPDM suitable for temperatures to 230 degrees F.

4. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
5. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

    a. Couplings: Ductile iron standard couplings, Style 77; lightweight couplings, Style 75; and rigid couplings. Reducing couplings are not acceptable.
    b. Flanges: Ductile iron Style 741 or 742 except at lug type butterfly valves where standard welding flanges shall be used.

6. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

I. The following services may use mechanical grooved pipe connections in exposed areas within the building in mechanical spaces, Bus Circulation/Storage Areas, and Service Lane. Mechanical chases are not considered accessible.

1. Heating Hot Water.

J. Acceptable fittings and couplings are listed below, based on Victaulic. When used on galvanized piping, fittings and couplings shall be galvanized. When used on black steel piping, fittings and couplings shall have an enamel coating.

K. Fittings: Ductile iron elbows and tees of the manufacturer's standard line may be used in all sizes except bullhead tees will not be accepted. Fabricated steel fittings may be used in all sizes where fitting wall thickness conforms to standard weight pipe. Mechanical-T Style 920 fittings with malleable iron housings may be used for up to 2" outlet size.

2.4 JOINING MATERIALS

A. 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 otherwise 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.

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

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

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

E. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 TRANSITION FITTINGS

A. See specification section 23 05 00 “Common Work Results for HVAC.”

2.6 DIELECTRIC FITTINGS

A. See specification section 23 05 00 “Common Work Results for HVAC.”

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. See drawing mechanical piping and valve schedule for piping application requirements.

B. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
3. Victaulic grooved couplings, valves and fittings made of, or designed for use on, Type 304/304L stainless steel pipe alternative to copper.

C. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

D. Condensate-Drain Piping: Copper Type L pipe and fittings and solder joints.

E. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS ¾ ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install valves according to Section 23 05 23 "General-Duty Valves for HVAC Piping."

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2½ and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

T. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in 23 05 00 “Common Work Results for HVAC."

V. Install sleeve seals for piping penetrations of concrete walls. Comply with requirements for sleeve seals specified in 23 05 00 “Common Work Results for HVAC."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in 23 05 00 “Common Work Results for HVAC."

3.3 DIELECTRIC FITTING INSTALLATION

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

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

C. Dielectric Fittings for NPS 2½ to NPS 4: Use dielectric flanges.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 23 05 48.13 "Vibration Controls for HVAC" for restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

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

1. NPS ¾: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1½: Maximum span, 9 feet.

4. NPS 2: Maximum span, 10 feet.
5. NPS 2½: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS ¾: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1½: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2½: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. 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.

E. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.6 GASKETS

A. Store horizontally in cool, dry location and protect from sunlight, water and chemicals. Inspect flange surfaces for warping, radial scoring or heavy tool marks. Inspect fasteners, nuts and washers for burrs or cracks. Replace defective materials.

B. Align flanges parallel and perpendicular with bolt holes centered without using excessive force. Center gasket in opening. Lubricate fastener threads, nuts and washers with lubricant formulated for application.

C. Draw flanges together evenly to avoid pinching gasket. Tighten fasteners in cross pattern sequence (12 – 6 o'clock, 3 – 9 o'clock, etc.), one pass by hand and four passes by torque wrench at 30% full torque, 60% full torque and two passes at full torque per ASME B16.5.

3.7 MECHANICAL GROOVED PIPE CONNECTIONS

A. Use pipe factory grooved in accordance with the coupling manufacturer's specifications or field grooved pipe in accordance with the same specifications using specially designed tools available for the application.

B. Lubricate pipe and coupling gasket, align pipe, and secure joint in accordance with the coupling manufacturer's specifications.

C. Support pipe as indicated in Section 23 05 29 of these specifications except as modified below. Support each horizontal pipe section at least once between couplings and whenever a change in direction of line flow takes place. Support vertical pipe at every other floor or every other pipe length, whichever is most frequent. Set the base of the riser or the base fitting on a pedestal or foundation.

D. Follow coupling manufacturer's installation recommendations if they are more stringent that the above requirements.

3.8 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 05 19 "Meters and Gages for HVAC Piping."

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate existing expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set existing makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all unit heaters are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as existing boilers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

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SECTION 23 21 16
HYDRONIC 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 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.

1.3 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.

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. Condensate-Drain Piping: 150 deg F.
3. Air-Vent Piping: 200 deg F.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 00 "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

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

a. Armstrong Pumps, Inc.

b. Bell & Gossett Domestic Pump.
c. Flow Design Inc.
d. Gerand Engineering Co.
e. Griswold Controls.
f. Nexus Valve, Inc.
g. Taco.
h. Tour & Andersson; available through Victaulic Company.

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).

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.
e. 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).

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 2½ (DN 65) and larger.

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 in the return pipe of each heating terminal.

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.

END OF SECTION 23 21 16

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SECTION 23 25 13
WATER TREATMENT FOR CLOSED-LOOP HYDRONIC 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 DEFINITIONS

A. 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.

B. 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.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Chemical material safety data sheets.
2. Pretreatment and chemical treatment equipment.

1.4 INFORMATIONAL SUBMITTALS

A. None.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: A minimum five years experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Fremont Industries
2. H-O-H Water Technology, Inc.
3. IWM Corporation
4. Nalco; an Ecolab company.
5. Watertech of America, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic 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, 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.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Use Existing Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3½-inch fill opening in the top, and NPS ¾ 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: 2 gal.
2. Minimum Working Pressure: 125 psig.

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.

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. Use existing water testing equipment on wall near water chemical application equipment in existing mezzanine boiler room.

B. Existing Bypass Feeders: Install in closed hydronic systems, including hot-water heating, and equipped with the following:

1. Use existing bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Use existing water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.

3.3 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 existing 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 hydronic systems' 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. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

3.4 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 23 25 13

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.

B. Related Sections:

1. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Indicated duct sizes are inside clear dimensions.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Include manufacturer's data and/or Contractor data for the following:

a. Fabrication and installation drawings.
b. Schedule of duct systems including material of construction, gauge, pressure class, system class, method of reinforcement, joint construction, fitting construction, and support methods, all with details as appropriate.
c. Duct sealant and gasket material.

d. Duct liner including data on thermal conductivity, air friction correction factor, and limitation on temperature and velocity.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Construct all ductwork to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions. Objectionable conditions shall be corrected to the satisfaction of the Owner, at no cost to the Contract.

1.6 DELIVERY, STORAGE AND HANDLING

A. Promptly inspect shipments to ensure that Ductwork is undamaged and complies with the specification.

B. Protect Ductwork against damage.

C. Protect Ductwork by storing inside or by durable, waterproof, above ground packaging. Do not store material on grade. Protect Ductwork from dirt, dust, construction debris and foreign material. Where end caps/packaging are provided, take precautions so caps/packaging remain in place and free from damage.

D. Offsite storage agreements do not relieve the contractor from using proper storage techniques.

E. Storage and protection methods must allow inspection to verify products.

PART 2 - PRODUCTS

2.1 GENERAL

A. All sheet metal used for construction of duct shall be 24 gauge or heavier except for round and spiral ductwork and spiral duct take-offs 12” and below may be 26 gauge where allowed in SMACNA HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005.

B. Duct sizes indicated on plans are net inside dimensions; where duct liner is specified, dimensions are net, inside of liner.

2.2 DUCTWORK PRESSURE CLASS

A. Minimum acceptable duct pressure class, for all ductwork except transfer ductwork, is 3-inch W.G. positive or negative, depending on the application. Transfer ductwork minimum acceptable duct pressure class is 1-inch W.G. positive or negative, depending on the application. Refer to Ductwork Schedule on drawings.

2.3 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. All longitudinal seams shall be “Pittsburgh” style.
2. Cross break or bead duct sides that are 11" and larger and are 20 gauge or less, with more than 4 sq. ft. of unbraced panel area. Crossbreaks shall be “out” on positive pressure duct and “in” on negative pressure ducts.
3. Internal standing seam joints also not allowed.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Exterior Surface Galvanized Coating Designation: G90.
2. Interior Surface Galvanized Coating Designation: G90.

    a. Sections Not Exposed to Moisture: G90.

F. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed work and No. 3 finish for exposed work.

1. Duct Joints for Stainless Steel Ducts:

    a. All sizes: Welded longitudinal seam joint construction.

2.4 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

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

    a. Lindab Inc.
    b. McGill AirFlow LLC.
    c. SEMCO Incorporated.
    d. Sheet Metal Connectors, Inc.
    e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
    2. No button punch snaplock construction permitted.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

    1. Exterior Surface Galvanized Coating Designation: G90.
    2. Interior Surface Galvanized Coating Designation: G90.

        a. Sections Not Exposed to Moisture: G90.

F. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed work and No. 3 finish for exposed work.

    1. Duct Joints for Stainless Steel Ducts:

        a. All sizes: Welded longitudinal seam joint construction.

2.5 SHEET METAL MATERIALS

A. See drawing schedule for sheet metal material requirements.

B. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 3/8-inch minimum diameter for lengths longer than 36 inches. Use external reinforcement angles stainless steel for Service Lane's stainless steel ductwork; no internal tie rods.

1. Internal tie rods bracing will not be accepted on ductwork below 36 inches.

H. Provide paint grip type ductwork where ductwork is exposed and indicated to be painted.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Hanger Rods for Service Lane: Use stainless steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments.

D. Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

1. No duct straps allowed for hanging ductwork.

E. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

F. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

G. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

1. For Service Lane: Use stainless steel assemblies with brackets, swivel, and bolts designed for duct hanger service.

H. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

I. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

2.8 SERVICE LANE AREA

A. In exposed areas in Service Lane Area, use 18 gauge or heavier stainless steel with a number 3 finish and with all joints welded liquid tight or prefabricated Underwriters

Laboratory, Inc listed duct with stainless steel shell. Grind and polish all welded joints and seams to a number 3 finish.

B. Provide expanded take-offs for branch duct connections or 45 degree entry fittings. Square edge 90 degree take-off fittings or straight taps will not be accepted.

C. Use elbows and tees with a center line radius to width or diameter ratio of 1.5 wherever space permits shall be used wherever possible. Shorter radius elbows may be used in areas with limited space with prior approval of the Architect/Engineer.

D. No turning vanes may be used in exhaust duct.

E. Supporting steel and hangers shall not be lighter than the duct gauge.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1½ inches.

1. Where ductwork passes through walls, floors, or ceilings of finished “Service Lane” provide stainless steel flange around penetration.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Ductwork sleeves in “Service Lane” shall be formed with 304 stainless steel.

N. Ductwork sleeves outside of “Service Lane” areas shall be formed with galvanized steel.

O. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

P. At ends of ducts not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering until time connections to be completed.

Q. Sizing Variation: No variation of duct configuration or sizes permitted except by written permission from Architect/Engineer

R. Drain Pockets:

1. Provide form drain pocket in outdoor air, dishwasher exhaust, any duct carrying high-moisture air, and humidifier sections with deep seal traps.
2. Connect to drainage system.

S. Provide expanded take-offs for branch duct connections or 45 degree entry fittings. Square edge 90 degree take-off fittings or straight taps will not be accepted

T. Size Change:

1. Increase and decrease duct sizes gradually, not exceeding 20 degrees divergence and 30 degrees convergence from connecting upstream duct surface, unless otherwise noted on drawings.
2. Maximum divergence upstream of equipment to be 20 degrees and maximum convergence downstream to be 30 degrees.

U. Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1½ inches.

1. Where ductwork passes through walls, floors, or ceilings of finished “Service Lane”, provide stainless steel flange around penetration.

V. Install duct to pitch as indicated on the drawings.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Install duct to pitch toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.

B. Fabricate seams and joints liquid-tight with continuous exterior welds or gasketed, bolted flanged connections in following locations:

1. Lower 6 inches of horizontal outdoor air ducts.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SERVICE LANE AREA

A. Welded joints are used with black steel duct, coat all external welded joints and seams with paint. Grind and polish to #3 finish all exposed stainless steel joints and seams.

B. Apply bracing and reinforcement to the outside of the duct to prevent breathing, rattling, vibration or sagging of duct.

C. Install without forming dips, sag or traps which might collect residue by supporting at not greater than 5-foot intervals; fasteners at hangers shall not penetrate the duct. Do not use sheet metal screws on supports; use bolted, riveted or welded connections. Where ductwork is listed, install in accordance with listing.

D. Construct tight access doors of the same material and thickness as the duct and as large as possible, up to 24 inches in any dimension. Locate on duct sides for ease of inspection and cleaning at each smoke detector and not less than 1½ inches from the bottom of the duct.

E. Pitch horizontal ducts at 1 inch per foot to air terminal outlet or other drain point detailed on the drawings.

F. The light test: A leakage test shall be performed. The ductwork contractor is required to pass a 100-watt lightbulb through the entire section of ductwork to demonstrate that all welded joints are liquid tight, including the duct connection to unit.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Make-up air unit internal surfaces and components including mixing box, heat-pipe coil section, condensate drain pans, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

D. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. See drawing schedule for duct pressure, seal and leakage class, and elbow configuration.

B. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. 304 Stainless Steel: “Service Lane”.

C. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

D. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

    a. Velocity 1000 fpm or Lower: 90-degree tap.
    b. Velocity 1000 to 1500 fpm: Conical tap.
    c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

A. Product data to include but not be limited to:

1. Dimensional and weight data
2. Temperature/Pressure ratings
3. Manufacturer’s name and model number
4. Materials of construction
5. Sealant and gasket materials
6. Manufacturer’s installation instructions.
7. Capacities and performance

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

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

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, ¼-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

    a. Air Balance Inc.; a division of Mestek, Inc.
    b. American Warming and Ventilating; a division of Mestek, Inc.
    c. Flexmaster U.S.A., Inc.
    d. Greenheck.
    e. McGill AirFlow LLC.
    f. Nailor Industries Inc.
    g. Pottorff.
    h. Ruskin Company.
    i. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Frame: Hat-shaped, 0.05-inch- thick stainless steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Stainless-steel, 0.064 inch thick.

6. Blade Axles: Stainless steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a ¾-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

A. Basis-of-Design Product: The design is based on the following:

1. Tamco Series 1500.

B. Outdoor-Air Damper: Extruded aluminum frame, opposed-blade extruded profile dampers with extruded silicone blade seals secured in integral aluminum extrusions and jamb seals, having a maximum leakage of 8 cfm/sq. ft. of damper area, at a differential pressure of 4-inch wg.

C. Exhaust Air Damper: Extruded aluminum frame, opposed-blade extruded profile dampers with extruded silicone blade seals secured in integral aluminum extrusions and jamb seals, having a maximum leakage of 8 cfm/sq. ft. of damper area, at a differential pressure of 4-inch wg.

D. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence. Equivalent to Belimo actuator.

2.5 TURNING VANES

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. METALAIRE, Inc.
5. SEMCO Incorporated.
6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.6 MIST ELIMINATOR

A. Mist eliminator separator for keeping water droplets, fog or droplets out of exhaust fan wheel and damper for EF-2 and EF-3 for of a building ventilation system. Separator shall high efficiency droplet separation and low pressure drop even at high face velocity.

B. Basis-of-Design Product: The design is based on the following:

1. Munters DF2100 Droplet Separator.
2. Munters DF2500 Mist Eliminator.
3. AmerVane VI
4. Agilis Technlogies HF3

C. Alternate for stainless steel mist eliminator filter may be substituted from the manufacturers listed in the following sections provided the materials of construction equal the basis of design, and the layout and scheduled performance is maintained. Final approval of substitutions will be determined by Engineer.

1. Flanders MS/MSG.

a. Separators shall have a minimum efficiency of 98% on 20 micrometer water or oil droplets when operated at 500 fpm gross face velocity.
b. Contractor to provide field fabricated housing for Flander's moisture eliminator filter. Provide access doors and drain pan for filter assembly.

D. Frames:

1. Minimum 16 gage, 0.0625-inch thick, 304 stainless sheet steel.
2. Mitered and welded corners.
3. Duct mounted: Flanged.

E. Performance

1. Operating range: 450-1200 FPM.
2. Temperature range: 40 – 200 deg F.
3. Maximum pressure drop: 0.30 WC.
4. Minimum water droplets < 20 microns at 80 percent efficiency.

F. Provide drain connection which water drains through the bottom into a tray. Coordinate drain position with manufacturer.

G. Coordinate with manufacturer for application and guideline requirements in sizing mist separator for pitch, spacing and radius requirements.

2.7 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.

3. Ductmate Industries, Inc.
4. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.
10. Ventfabrics, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

    a. Double wall, rectangular.
    b. Stainless steel 304 sheet metal with insulation fill and thickness as indicated for duct pressure class.
    c. Vision panel.
    d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
    e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: 304 Stainless sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches Square: Two hinges or Continuous and with two sash locks.
    c. Access Doors up to 24 by 48 Inches: Three hinges or Continuous and with two compression latches.

2.8 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3½ inches wide attached to two strips of 2¾-inch- wide, 0.028-inch- thick, 304 stainless steel. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.9 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel, and stainless-steel accessories in stainless-steel ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install mist eliminator according to manufacturer’s guidelines. Provide duct transitions to flange connections of the duct assembly. Contractor shall extend drain to nearest wall and down to floor. Provide a drain ball valve.

E. Install volume dampers at points on supply, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install galvanized steel volume dampers in galvanized steel ducts.
2. Install stainless steel volume dampers in stainless steel ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. At outdoor-air intakes and mixed-air plenums.
3. At drain pans and seals.
4. At each change in direction and at maximum 50-foot spacing.
5. Upstream and downstream from turning vanes.
6. Control devices requiring inspection.
7. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 12 by 12 inches.
2. Two-Hand Access: 12 by 12 inches.
3. Head and Hand Access: 18 by 12 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Install duct test holes where required for testing and balancing purposes.

N. Access doors constructed with sheet metal screw fasteners will not be accepted

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Inspect turning vanes for proper and secure installation.
4. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

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SECTION 23 34 00
FUME EXHAUST EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Fan speed controllers.
7. Vibration isolators.

B. Operation and Maintenance Data: For fume exhaust equipment to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.5 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 VEHICLE EXHAUST REEL SYSTEM

A. Available Manufacturers:

1. Car-Mon
2. Plymovent
3. Ventaire, Inc.
4. Nederman
5. Airflow Systems Inc.

B. Tubing:

1. Abrasion resistant, fire retardant, heat resistant, high tensile strength material to withstand exhaust temperatures up to 600°F.
2. Interior spring-steel wire reinforcement.
3. Exhaust adapters, guide rings, flanges, etc., as required, shall be factory attached to ensure assembly integrity.
4. Tubing length and diameter shall be as scheduled.
5. In addition to the tubing on the reel, provide an additional 25' length of tubing with swivel socket fittings on each end for attachment to other tubing or adaptors.

C. Tailpipe Connector:

1. Tapered cone adaptors to fit over tail pipes of all vehicles. Adaptors shall be constructed of minimum 20 gage stainless steel.
2. Adapter shall include heat resistant handles for easy handling, spring clip for tailpipe attachment, emission testing opening, and extension and retraction cable and ring.
3. Provide swivel socket fittings for attachment to adaptor. Fitting shall be able to rotate 360° at an approximate 30° angle in any direction.

D. Tubing Reel:

1. Welded frame: Formed 12-gauge and 3/16" thick steel.
2. Tubing drum: 16-gauge steel welded to 12-gauge steel end plates, forming an airtight cylinder.
3. Discharge collar: Provided on reel to facilitate duct connection.

4. Minimum tube length capacity: 25 feet
5. Mounting: As shown on the plans.

E. Tubing Reel Drive:

1. Motorized: 115-Volt/1-phase/60-hertz, ¼ hp reversible gear motor controlled by an adjustable limit switch and a contactor relay. The complete unit will be factory-mounted directly to the tubing storage reel.

F. Flange Mounted Fan:

1. Single inlet, single width, backward inclined, non-overleading type. Statically and dynamically balanced.
2. Housing: Heavy gauge cold rolled steel of all welded construction.
3. Corrosion protection: Heresite air-dry phenolic coating on all fan and wheel components.
4. Electrical: Fan motor shall be an industrial grade, high efficiency, C-face type, bolted directly to the housing. See plan schedule for electrical ratings.
5. Fan shall attach directly to boom arm.

G. Accessories:

1. Wall mounted remote push button station for reel drive.
2. Magnetic exhaust nozzle grabber.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1-inch. Vibration-control devices are specified in Division 23 05 48.13 Section "Vibration Controls for HVAC."

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 23 05 53 " Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 “Air Duct Accessories”.

B. Ground equipment according to Division 26.

C. Connect wiring according to Division 26.

D. Provide safety screen(s) when fan inlet or outlet is exposed.

E. Where fan inlet or outlet ducting has been changed from that shown on the drawings, provide any motor, drive, and/or electrical system changes required to increase static pressure.

F. On units provided with a drain connection, install a drain valve and cap discharge of drain.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

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

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

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

E. Lubricate bearings.

END OF SECTION 23 34 00

SECTION 23 34 23
HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

C. Each fan system shall be capable of delivering 110% of the scheduled airflow at the scheduled static pressure. The fan motor shall not operate into the motor service factor when operating under these conditions.

D. Drive efficiency shall be considered when selecting motors in accordance with manufacturer's recommendations or according to AMCA Publication 203, Appendix L.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.
8. Wiring Diagrams: For power, signal, and control wiring.
9. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Penn.
4. Twin City.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
3. Nameplate: Include aluminum engraved nameplate with unit manufacturer, model number, and performance data.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing. ECM motor arrangement.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.
6. Bearings for belt drive units shall be selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, ½-inch mesh, aluminum or brass wire.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
5. Bird screens.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1½-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1½-inch wood nailer. Size as required to suit roof opening and fan base.

1. Overall Height: 24 inches.
2. Sound Curb: Curb with sound-absorbing insulation.
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to 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. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 7 for installation requirements to integrate with the roof system.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Install ducts adjacent to power ventilators to allow service and maintenance.

B. Ground equipment according to Division 26.

C. Connect wiring according to Division 26.

D. Provide safety screen(s) when inlet or outlet is exposed.

E. Where fan inlet or outlet ducting has been changed from that shown on the drawings, provide any motor, drive, and/or electrical system changes required to increase static pressure.

F. On units provided with a drain connection, install a drain valve and cap discharge of drain.

3.3 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.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

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

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

C. Lubricate bearings.

END OF SECTION 23 34 23

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SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 REGISTERS AND GRILLES

A. Adjustable Bar Register:

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

    a. Krueger.
    b. KEES Inc.
    c. METALAIRE, Inc.
    d. Nailor Industries Inc.
    e. KEES Inc.
    f. Price Industries.
    g. Titus.
    h. Tuttle & Bailey.

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Frame: See Air Outlets and Inlets Schedule on drawings.
5. Mounting: See Air Outlets and Inlets Schedule on drawings.
6. Damper Type: See Air Outlets and Inlets Schedule on drawings.

B. Adjustable Bar Grille:

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

a. Krueger.
b. KEES Inc.
c. METALAIRE, Inc.
d. Nailor Industries Inc.
e. KEES Inc.
f. Price Industries.
g. Titus.
h. Tuttle & Bailey.

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Frame: See Air Outlets and Inlets Schedule on drawings.
5. Mounting: See Air Outlets and Inlets Schedule on drawings.

C. Fixed Face Register:

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

a. Krueger.
b. KEES Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus.
f. Tuttle & Bailey

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Face Arrangement: ½-by-½-by-½-inch grid core.
5. Frame: See Air Outlets and Inlets Schedule on drawings
6. Mounting: See Air Outlets and Inlets Schedule on drawings.
7. Damper Type: See Air Outlets and Inlets Schedule on drawings.

D. Fixed Face Grille:

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

a. Krueger.
b. KEES Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus.
f. Tuttle & Bailey.

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Face Arrangement: ½-by-½-by-½-inch grid core.
5. Core Construction: Integral.

6. Frame: See Air Outlets and Inlets Schedule on drawings wide.
7. Mounting: See Air Outlets and Inlets Schedule on drawings.

2.2 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. 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. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

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

END OF SECTION 23 37 13

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SECTION 23 41 00
PARTICULATE AIR FILTRATION

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 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.4 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. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.
2. Provide one container(s) of red oil for inclined manometer filter gage.

1.5 QUALITY ASSURANCE

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

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

D. Supply all filters from one manufacturer, unless indicated otherwise.

E. Assemble filter components to form filter banks from one manufacturer.

F. Filter frames and support structures shall be fabricated by equipment manufacturers.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

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

a. AAF International.
b. Camfil Farr.
c. Filtration Group.
d. Flanders-Precisionaire.
e. Purafil, Inc.
f. Research Products Corp.

B. Filter Unit Class: UL 900, Class 2.

C. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall 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."
2. Media shall be coated with an antimicrobial agent.
3. Separators shall be bonded to the media to maintain pleat configuration.
4. Welded wire grid shall be on downstream side to maintain pleat.
5. Media shall be bonded to frame to prevent air bypass.
6. Support members on upstream and downstream sides to maintain pleat spacing.

D. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. See schedule on drawings.
2. MERV Rating: Per scheduled value when tested according to ASHRAE 52.2.

2.2 DISPOSABLE RIGID CARTRIDGE TYPE AIR FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.

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

a. AAF International.
b. Camfil Farr.
c. Filtration Group.
d. Flanders-Precisionaire.
e. Purafil, Inc.
f. Research Products Corp.

B. Filter Unit Class: UL 900, Class 1.

C. Media: 4” deep fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible corrugated aluminum internal supports.

1. Adhesive shall 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."
2. Media shall be coated with an antimicrobial agent.

D. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

E. Capacities and Characteristics:

1. See schedule on drawings.
2. MERV Rating: Per scheduled value when tested according to ASHRAE 52.2.

2.3 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

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

a. Airguard.
b. Dwyer Instruments, Inc.

2. Diameter: 4½ inches.
3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of the full-scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air system unit installations.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

B. Air filter will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Operate installed air filters and housings to demonstrate compliance with specifications.

E. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing of make-up air-handling units, energy recovery ventilators and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00

SECTION 23 51 00
BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Type B and BW vents.
2. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.

1.3 QUALITY ASSURANCE

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

1.4 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "EPDM Roofing System."

PART 2 - PRODUCTS

2.1 LISTED TYPE B VENTS

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

1. Heat-Fab, Inc.
2. Metal-Fab, Inc.
3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
4. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F continuously for Type B, or 550 deg F continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a ¼-inch airspace.

D. Inner Shell: ASTM A 666, Type 430 stainless steel.

E. Outer Jacket: steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Exit cone with drain section incorporated into riser.

2.2 COMBUSTION AIR VENTS AND EXHAUST FOR CONDENSING APPLIANCES

A. Provide combustion air vents, fittings, and accessories constructed of schedule 40 CPVC where in accordance with appliance manufacturer's recommendations.

B. Size combustion air vents in strict accordance with appliance manufacturer's requirements.

2.3 GUYING AND BRACING MATERIALS

A. Cable: Three galvanized, stranded wires of the following thickness:

1. Minimum Size: ¼ inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16 inch.

B. Pipe: Two galvanized steel, NPS 1¼.

C. Angle Iron: Two galvanized steel, 2 by 2 by 0.25 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

3.2 APPLICATION

A. Listed Type B Vents: Vents for certified gas appliances.

1. Gas Unit Heaters
2. Duct Furnaces.

B. Listed CPVC Vents: Vents for certified gas appliances.

1. Condensing Water Heaters – Bus Wash

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect breeching plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

3.4 GUY WIRE INSTALLATION

A. Provide manufacturer's guy bands once stack above fixed height above roof exceeds 7½ feet.

B. Space guys maximum 10 feet o.c.

C. Maximum free section height above top guy band: 7 feet.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 00

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SECTION 23 55 13.16
GAS-FIRED DUCT 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 gas-fired duct heaters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired duct heater.

1. Include rated capacities, operating characteristics, and accessories.
2. Include diagrams for signal and control wiring.
3. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired duct heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired duct heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GAS FIRED DUCT HEATERS

A. Basis-of-Design Product: The design is based on the following:

1. Modine Mfg. Co.: Model DFP.

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. Lennox International, Inc.
2. Reznor/Thomas & Betts Corporation.
3. Sterling HVAC Products; Div. of Mestek Technology Inc.
4. Renewaire GH Series

2.2 PERFORMANCE 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.

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.8/CSA 2.6.

B. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

C. 80% Efficiency - standard thermal efficiency for gas-fired duct furnace.

D. Indoor External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.

1. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.

E. Tube Material: 304 Stainless steel.

F. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.

G. Power Venter: Integral, motorized centrifugal fan interlocked with gas valve.

H. Provide disconnect switch and mounted on furnace.

I. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

J. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Ignition: Electronically controlled direct electric spark ignition with flame sensor.
2. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
3. Vent Flow Verification: Differential pressure switch to verify open vent as Air Proving Switch.
4. Combustion Air Pressure Switch.
5. Manual reset flame rollout switch
6. Control transformer.

7. High Limit: Thermal switch or fuse to stop burner.

2.4 CONTROL

A. Control are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls."

2.5 CAPACITIES AND CHARACTERISTICS:

A. Refer to Schedule on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired duct heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

1. Spring hangers are specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements in Section 23 05 48.13 "Vibration Controls for HVAC" for spring hangers.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Clean dust and debris from each unit as it is installed. Comb out damaged fins where bent or crushed before covering elements with enclosures.

3.3 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 gas-fired duct heaters, allow space for service and maintenance.

C. Gas Piping: Comply with “Section 23 11 23 "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Vent Connections: Comply with Section 23 51 00 "Breechings, Chimneys, and Stacks."

E. Duct Connections: Comply with “Section 23 31 13 "Metal Ducts."

F. Ground equipment according to Division 26.

G. Connect wiring according to Division 26.

3.4 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. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired duct heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

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

END OF SECTION 23 55 13.16

SECTION 23 55 33.16
GAS-FIRED UNIT 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 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.
2. Include diagrams for signal and control wiring.
3. Sample Warranty: For special warranty.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.
2. Five (5) year heat exchanger, flue collector and burner warranty.

PART 2 - PRODUCTS

2.1 GAS-FIRED UNIT HEATERS

A. Basis-of-Design Product: The design is based on the following:

1. Sterling HVAC Products; Div. of Mestek Technology Inc.

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. Lennox International, Inc.
2. Modine Manufacturing Company.
3. Reznor/Thomas & Betts Corporation.

2.2 PERFORMANCE 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.

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.

B. Gas Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

C. Type of Venting: Indoor, separated combustion, power vented.

D. Housing: Stainless steel, with integral draft hood and inserts for suspension mounting rods.

1. External Casings and Cabinets: 20-gauge stainless steel jacket and components.
2. Discharge Louvers: Independently adjustable, horizontal blades.

E. Accessories:

1. Four-point suspension kit.
2. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

F. Heat Exchanger: 20-gauge, 409 stainless-steel.

G. Burner Material: 409 stainless-steel inserts.

1. Direct spark pilotless ignition of the burner.
2. In-shot burner technology.
3. Power vent.

H. Propeller Unit Fan:

1. Formed-steel propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
2. Fan-Blade Guard: stainless steel, complying with OSHA specifications, removable for maintenance.
3. Individually adjustable and removable louvers

I. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

J. Electrical Connection: Factory wire motors and controls for a single electrical connection.

K. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Single stage.
2. Ignition: Electronically controlled electric spark with flame sensor.
3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
4. Vent Flow Verification: Differential pressure switch to verify open vent.
5. Control transformer.
6. High Limit: Thermal switch or fuse to stop burner.
7. Thermostat: Built-in stat.

2.4 CONTROL

A. Control are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls."

2.5 CAPACITIES AND CHARACTERISTICS:

A. Refer to Schedule on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

1. Spring hangers are specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements in Section 23 05 48.13 "Vibration Controls for HVAC" for spring hangers.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Clean dust and debris from each unit as it is installed. Comb out damaged fins where bent or crushed before covering elements with enclosures.

3.3 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 gas-fired unit heater, allow space for service and maintenance.

C. Gas Piping: Comply with Section 23 11 23 "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Vent Connections: Comply with Section 23 51 00 "Breechings, Chimneys, and Stacks."

E. Ground equipment according to Division 26.

F. Connect wiring according to Division 26.

3.4 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. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

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

END OF SECTION 23 55 33.16

SECTION 23 72 00
AIR-TO-AIR ENERGY RECOVERY 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. Packaged energy recovery units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For air-to-air energy recovery equipment. 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. Delegated-Design Submittal: For air-to-air energy recovery equipment 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 air-to-air energy recovery equipment.
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.
3. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

B. Submit manufacturer’s installation instructions.

C. Submit dimensioned drawings showing accurately scaled equipment and components, and required clearance and space relationships.

D. Include fan curves showing CFM, external and total static pressure, and RPM for operating range of 10% above and below design conditions.

E. Submit manufacturer's descriptive literature including equipment efficiencies at design conditions; temperature and pressure ratings; materials of construction; weights; and control sequencing and interface.

1.5 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 of each type of filter specified.

1.6 QUALITY ASSURANCE

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

B. ARI Compliance:

1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
3. The results shall be presented in accordance with ARI 1060 standards.

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

E. UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

1.7 COORDINATION

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

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy Recovery Units: Two (2) years.

PART 2 - PRODUCTS

2.1 PACKAGED ENERGY RECOVERY UNITS

A. Basis-of-Design Product: The design is based on the following:

1. Greenheck Fan Corporation, Model ECV

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. RenewAire LLC.
2. Lossnay - Mitsubishi

C. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and calked weathertight, hinged access doors removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1-inch- thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.

1. Casing shall be single-wall.
2. Casing Insulation: Minimum 1 inch thick 1.5 lb density thermal insulation.
3. The rotor housing must limit the deflection of the rotor due to air pressure to less than 1/32".

E. Heat Recovery Device: Static-core technology, enthalpic-core as fixed-plate heat exchanger.

F. Supply and Exhaust Fans: Forward-curved, centrifugal fan with spring isolators and flexible duct connections.

1. Motor and Drive: Direct driven Drive type indicated on Drawings.
2. Electronically Commutated Motors. (ECM)
3. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

4. 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.
5. Spring isolators on each fan having 1-inch static deflection.

G. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. 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 lift out from access plenum.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: 2 inches.
5. Initial Resistance: 0.25 inches wg.
6. Recommended Final Resistance: 0.5 inches wg.
7. Minimum Arrestance: 80, according to ASHRAE 52.1.
8. Minimum Merv: 7, according to ASHRAE 52.2.
9. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

H. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.

1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Include fused disconnect switches.
3. ECM variable-speed controller to vary fan capacity from 100 to approximately 50 percent.

I. Accessories:

1. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed parallel-blade arrangement with cadmium-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.
2. Isolation Dampers: Opposed-blade, galvanized-steel dampers with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
3. Duct flanges.
4. Rubber-in-shear isolators for ceiling-mounted units.
5. Hinged access doors with quarter-turn latches.
6. Drain pans for condensate removal complying with ASHRAE 62.1.
7. Automatic, in-place, spray-wash system.

2.2 CONTROL

A. Control are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls."

2.3 CAPACITIES AND CHARACTERISTICS:

A. Refer to Schedule on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

B. Install units with clearances for service and maintenance.

C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

D. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

E. Pipe drains from drain pans to nearest floor drain.

3.3 CONNECTIONS

A. Connect condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

B. Install electrical devices furnished with units but not factory mounted.

C. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment piping, ducts, or other parts of the work, the Contractor shall

rectify such conditions to the satisfaction of the Owner without cost to the Contract. If the equipment is judged to produce objectionable noise or vibration, demonstrate without cost to the Contract that the equipment performs within the designated vibration limits specified.

D. Install thermometer at each side of both supply and exhaust air streams.

E. Install pressure gauge equal to Dwyer Series 2000 Magnehelic across unit in supply air stream.

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. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Adjust seals and purge.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Set initial temperature and humidity set points.
5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Before acceptance by Owner, unit manufacturer’s representative shall approve, and certify in writing, unit performance including heat transfer efficiency and air leakage quantities.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 00

SECTION 23 74 23.16
CUSTOM, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR 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 ACTION SUBMITTALS

A. Product Data: For each type and configuration of outdoor, indirect-fired makeup-air unit.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Fan curves showing CFM, external and total static pressure, and RPM for operating range of 10% above and below design conditions. Clearly indicate specified operating point.
3. Fan, type, bearings, and drive.
4. Materials of construction, including casing construction details and finishes.
5. Heat-Pipe heat exchanger's energy recovery device performance showing energy recovery capacity, effectiveness, face velocities, and summer and winter operating parameters.

B. Shop Drawings: For each type and configuration of outdoor, indirect-fired heating and ventilating unit.

1. Prepared by or under the supervision of a qualified professional engineer.
2. Include plans, elevations, sections, and mounting details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
5. Include diagrams for power, signal, and control wiring.

    a. Clearly indicate factory installed and field installed wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For indirect-fired makeup-air units to include in emergency, operation, and maintenance manuals.

1.4 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 for each unit.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. All materials shall meet NFPA 90A flame spread and smoke generation requirements.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of indirect-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

B. Warranty Period for Indirect Gas-Fired Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: The design is based on the following:

1. Venmar CES EnergyPack – Nortek Air Solution.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include for the following:

1. Innovent Air Handling Equipment.
2. Haakon Industries.
3. Addison

2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, exhaust fan, air-to-air energy recovery device, controls, filters, and indirect-fired gas burner to be installed exterior to the building.

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 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.

2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: Horizontal unit with bottom discharge and return inlet for roof-mounting installation.

C. Cabinet: Galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet. Pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Outer Casing: 0.0598-inch-thick steel with over-corrosion-resistant-treated surface in color to match fan section finish.

E. Exterior finish shall be factory applied high build (3 to 5 mils) alkyd enamel or epoxy coating. Coating shall pass ASTM B-117 1,000 hour salt spray test. Color shall be manufacturer’s standard grey.

F. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch-thick steel.
2. Double-wall casing with inner wall of solid steel, for the following sections:

    a. Discharge plenum.
    b. Indirect-fired gas burner
    c. Fan section.
    d. Heat Pipe Coils
    e. Filter section.
    f. Inlet plenum.
    g. Access Doors: Hinged with handles for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: Fibrous-glass insulation or polyisocyanurate or urethane, or polyurethane insulation.

    a. Thickness: Minimum 2 inches.
    b. Insulation Adhesive: Comply with ASTM C 916, Type I.
    c. Minimum R-value 12.5 for walls, roof and floor construction.
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

G. Roofs:

1. Construction of the roof shall be identical to the wall construction specified.
2. Unit roof for outdoor units are to be sloped a minimum pitch of ¼" per foot.
3. The roof shall overhang all side and end panels to prevent precipitation drainage from streaming down the unit wall panels. Gutter systems are not acceptable.
4. Roof construction shall accommodate a minimum snow-load of 30 lb/ft2.
5. Roof shall be designed to hold a 300lb load for service and maintenance.
6. Roofs less than 12' wide shall be sloped to the non-door side of the unit.

H. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:

    a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels 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. 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. Fabricate windows indoors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
    d. Size: At least 24 inches wide by full height of unit casing up to a maximum height of 60 inches.

4. Locations and Applications:

    a. Fan Section: Doors.
    b. Damper Section: Doors.
    c. Filter Section: Doors large enough to allow periodic removal and installation of filters.
    d. Heat Pipe Energy Recovery Device: Doors to allow access to all sections of the Heat Pipe Energy Recovery Device.
    e. Burner Section: Pilot and main flame observation ports.

5. LED Service Light: 100-W vapor proof fixture with switched junction box located inside adjacent to door.

    a. Locations: Each section accessed with door. All lights shall be wired from the factory to a separate single junction box located on the exterior of the air handling unit.

I. Base Rails:

1. Type ASTM A36 welded structural steel c-channel, 6-inch height, with cross supports spaced at regular intervals and removable lifting lugs. Factory shall provide curb angle welded to the base for outdoor curb mounted units.

J. Condensate Drain Pans:

1. 18-gauge stainless steel fabricated with one percent minimum slope in at least two planes to collect condensate from condensate-producing heat exchangers and the Heat Pipe Energy Recovery device, to direct water toward drain connection.
2. Formed sections.
3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

    a. Minimum Connection Size: Drain pipe shall be schedule 40, 1¼" nominal, MPT stainless steel pipe.

4. All drain pan corners shall be welded.

2.4 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. All receptacles shall be wired from the factory to a separate junction box located on the exterior of the unit.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss. Refer to Section 23 41 00 - Particulate Air Filtration.

2.5 INTAKE/EXHAUST HOODS

A. Type: Manufacturer's standard hoods for outside air inlet and exhaust air discharge.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.6 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C 1071, Type I or Type II.
    b. Thickness: 2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    d. Liner Adhesive: Comply with ASTM C 916, Type I.

B. Curb Height: 18 inches.

2.7 SUPPLY-AIR AND EXHAUST AIR FANS

A. Fan Type: Centrifugal, polymer plenum fan; rated according to AMCA 210, statically and dynamically balanced.

B. Drive: Direct Drive with permanently sealed motor bearings are standard

C. Mounting:

1. Fan array shall consist of single or multiple fan and motor “cubes”, spaced in the airway tunnel cross section to provide a uniform airflow and velocity profile across the entire airway tunnel cross section and components contained therein. Each fan/motor assembly shall be removable through a 30” wide open area.
2. Fan array shall be provided with a rectangular or Coplanar silencer for sound absorption. Enclosure shall be constructed of aluminum or galvanized steel mesh or expanded metal and sized to have no measurable system effect on fan performance.

D. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at the scheduled static pressure. Fan motor shall be located on the door side of the blower.

E. Vertical FBD backdraft damper or equivalent for fan array systems for minimal system effect and low leakage of rate = 2 cfm/sq. ft. at 1” static pressure or 3.5 cfm / s q. ft. at 4” static.

F. Inlet Cones: Inlet cones shall be precision spun. Inlet cones shall be aerodynamically matched to wheel side plate to insure full loading of blades. Inlet cones shall be heavy gauge steel. Provide piezometer ring mounted at throat of inlet cone.

G. Shaft Grounding Ring (SGR): The VFD powered small AC motors shall have a single shaft grounding system to protect the bearings from capacitive discharge through the bearings. The shaft grounding system shall be AEGIS or equal. The shaft grounding system shall reduce the shaft to frame voltage below 3 volts (as measured with Fluke 97 oscilloscope), have low drag, be field installable with hand held tools, sealed to be resistant to weather and contaminants and require no periodic adjustments or

maintenance for a normal running life of five years at speed up to 1800 rpm. The grounding brush element must be changeable without shutting the motor down or using special tools.

2.8 AIR FILTERS

A. Comply with NFPA 90A.

B. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames.

1. Thickness: 4 inches, MERV 8.
2. Media: Interlaced glass fibers.
3. Frame: Stainless steel.
4. Maximum Face Velocity: 400 fpm.
5. Refer to Section 23 41 00 - Particulate Air Filtration.

2.9 DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include for the following:

1. Tamco Series 1500.

B. Outdoor-Air Damper: Extruded aluminum frame, opposed-blade extruded profile dampers with extruded silicone blade seals secured in integral aluminum extrusions and jamb seals, having a maximum leakage of 8 cfm/sq. ft. of damper area, at a differential pressure of 4-inch wg.

C. Exhaust Air Damper: Extruded aluminum frame, opposed-blade extruded profile dampers with extruded silicone blade seals secured in integral aluminum extrusions and jamb seals, having a maximum leakage of 8 cfm/sq. ft. of damper area, at a differential pressure of 4-inch wg.

D. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence. Equivalent to Belimo actuator.

2.10 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Aluminized steel with stainless-steel inserts.

a. Gas Control Valve: Modulating.
b. Fuel: Natural gas.
c. Minimum Combustion Efficiency: 80 percent.
d. Ignition: Electronically controlled electric spark with flame sensor.

3. Burner shall be factory-installed on the exchanger with all gas piping and control wiring required for the proper operation of the unit.
4. Provide pressure regulator, automatic quick-closing shut-off valve, automatic slow-opening valve, manual ignition cock, test ports and modulating gas valve.

B. Venting: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

C. Heat Exchanger: Stainless steel, in-shot burner type exchanger with minimum turndown ratio of at least 10:1.

1. The multiple pass heat exchanger shall be in-shot burner type, with entirely made of 304L stainless steel without the use of turbulators and requiring no thermal treatment to prevent weld cracking. The exchanger will be equipped with bolted access panels for the inspection and cleaning of the tubes. Note: 400 Series stainless steel, aluminized carbon steel heat exchangers are not acceptable.
2. Unit is 80% efficient and operate above condensing temperature.

D. Heat-Exchanger Drain Pan: Stainless steel.

E. Safety Controls:

1. Vent Flow Verification: Flame rollout switch.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas Manifold: Safety switches and controls complying with ANSI standards.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.11 HEAT-PIPE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, the following:

1. Heat Pipe Technology, Inc. (HPT)
2. Innergy Tech.
3. Munters.
4. AMS Energy.

B. Casing: 16 ga 304 Stainless Steel flanged casing, with airtight partition between airstreams. The supply and exhaust air streams shall be isolated from each other by, a

single separating partition, a double separating partition, or, a foam-filled double separating partition. Cross contamination between the air streams is not acceptable.

C. Refrigerant:

1. Circumferential capillary wick shall be an integral part of the inner wall of the tube to provide a completely wetted surface for maximum heat piping capacity with minimum heat transfer resistance. The capillary wick structure shall not degrade the structural integrity of the heat pipe wall. Capillary wick is not mandatory for heat pipes tested and certified to AHRI standard 1060. Testing in accordance with AHRI 1060, but not certified, will not be acceptable.
2. Provide intermediate core supports to limit sagging or bowing to 1/8" of the total end-to-end length.
3. Provide protective end covers to protect tube ends which extend through the casing.
4. Heat Transfer fluid shall be classified as Safety Group A1 in ASHRAE Standard 34-2013.
5. The Heat Pipes shall be ETL or UL listed to UL standard 207 and CSA standard C22.2.140.3
6. Each circuit shall be individually processed, charged, and hermetically sealed.

D. Tubes: ½ inch diameter, copper. Other diameters are acceptable provided it meets the required air pressure drop.

E. Fins: Aluminum.

1. Fin Spacing: 12 fins per inch maximum
2. Fin and Tube Joint: Silver brazed.

F. Coating: The Heat Pipe modules shall have an optional protective coating of, E-Coat, similar to Electrofin or, Phenolic, similar to Heresite. Coils shall be dipped and completely submerged to ensure full coverage of coating - spray coatings are not acceptable.

G. The entire heat transfer surface shall be visible for inspection and cleaning without removing the exchanger. The Heat Pipe heat exchanger shall have a five (5) year limited warranty.

H. Bypass Damper: The bypass damper shall bypass air around the supply side of the energy recovery heat pipe for economizer usage. Damper shall be of low leakage design. Blades and frames shall be made of roll formed galvanized steel or aluminum, minimum 16 gauge. Frames shall be constructed with hat shaped channels, reinforced, or with welded corners. Axles shall be plated steel. Dampers shall be incorporated with face linkage or concealed linkage in the frame to interconnect all the blades. Heat pipe shall be selected so that no frosting will occur at -20°F outside air and 60°F and 99%RH exhaust condition without frost control.

I. Tilt Optimization: No tilt controls allowed, but a static tilt to optimize heat recovery is acceptable to meet performance specified.

2.12 FAN INLET AIR FLOW STATIONS

A. Provide a piezometer ring air flow station mounted on the fan inlet bell housing. Pressure tubes from the piezometer ring shall be extended to a termination plate labeled with the high and low pressure connections. Provide an initial flow rate coefficient that will be adjusted by the balancing contractor for measured flow reading.

B. Piezometer ring air flow station shall measure static pressure drop through the fan inlet cone to provide an overall air flow measurement to within +/- 5% accuracy.

C. Differential pressure transducers for measuring the velocity pressure for air flow measurement shall be supplied under Section 23 09 00 and be mounted in the temperature control panel.

2.13 CONTROLS

A. Comply with requirements in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls" for control equipment and sequence of operation

B. All sensors, actuators, and variable frequency drives shall will be field provided and installed by the contractor in Section 23 09 00. Fans shall have circuit breakers or fuses, wired, and terminated to a junction box in the unit control panel.

2.14 ELECTRICAL ENCLOSURE

A. Unit manufacturer to provide a built-in electrical enclosure cabinet at minimum of 48-inches (w) x 60-inches (h) x 12-inches (d) to accommodate electrical services.

1. Coordinate with Temperature Control Contactor per Section 23 09 00.

    a. Contractor to coordinate with DanFoss VLT variable frequency drives and temperature control panel size requirements to be field installed.

B. Electrical enclosure cabinet shall be furnished with these accessories

1. Double duplex, 115-V, ground-fault-interrupter outlet with 15-A. Include transformer if required.
2. All receptacles shall be wired from the factory to a separate junction box located on the exterior of the unit.
3. LED Service Light: 100-W vapor proof fixture with switched junction box located inside adjacent to door.
4. (Qty.2) Microtech cooling fan and thermostat controlled for cabinet ventilation for wall mounted ABS weatherproof with 5 ft power cord,3-plong to duplex outlet vented to exterior. Exterior vents shall have bird screen wire or filter design. Similar cooling fans to Delvalle IP55 Prius series or equivalent.
5. Exterior Access Doors: At least 24 inches wide by full height of unit casing up to a maximum height of 60 inches.

2.15 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

B. Motor furnished with fan shall not operate into motor service factor in any case. Drive efficiency shall be considered in motor selection according to motor manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

C. If unit(s) submitted have larger motor power requirements than scheduled in the drawings, the contractor shall be responsible for any additional electrical system upgrade costs.

D. Motor enclosure: Totally enclosed, fan cooled (TEFC).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine 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 piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

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

3.2 INSTALLATION

A. Unit Support: Install heating and ventilating unit level on structural roof curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

B. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

C. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

D. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "EPDM Roofing System." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

E. Contractor to install two layers of 6-inch fiberglass batt insulation inside of the equipment roof curb for thermal barrier prior to setting of the unit.

3.3 CONNECTIONS

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

1. Gas Piping: Comply with requirements in Section 23 11 23 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Heat-Exchanger Drain Pans: Connect drain pan outlet to condensate drain lines that extend through interior roof curb and into the Service line space. Contractor to extend condensate drain line to hub drain below roof. Coordinate with plumbing contractor for location of hub drains.

C. Duct Connections: Connect supply and exhaust ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for flexible duct connectors.

1. Ensure that metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.

D. Ground equipment according to Division 26.

E. Connect wiring according to Division 26.

F. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. The Contractor shall be responsible for any motor, drive, and/or wiring changes required as result of duct configuration changes at fan. Obtain Approval before proceeding with changes to ductwork.

3.4 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. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup check according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to burner combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.

3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

8. After startup and performance testing, change filters, and verify bearing lubrication.
9. Verify drain-pan performance.
10. Verify outdoor-air damper operation.

3.6 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.7 DEMONSTRATION

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

END OF SECTION 23 74 23.16

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SECTION 23 81 26
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 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. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Gaskets: One set(s) for each access door.

1.5 QUALITY ASSURANCE

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

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.

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: The design is based on the following:

1. LG Air Conditioning Technologies.

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
2. Daikin
3. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
4. SANYO North America Corporation; SANYO Fisher Company.
5. Trane; a business of American Standard companies.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:

1. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
2. Fan: Direct drive, centrifugal.
3. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
    d. Mount unit-mounted disconnect switches on exterior of unit.

4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
5. Condensate Drain Pans:

    a. Fabricated with one 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.

6. Filters: Cleanable

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.
    b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Charge: R-410A.
    d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Refrigeration Components:

    a. Refrigerant circuit components shall include brass external liquid line service valve with service gage port connections, suction line service valve with service gage connection port, service gage port connections on compressor suction and discharge lines, accumulator, pressure relief, and a full charge of refrigerant.

6. Controls and Safeties:

    a. Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control functions shall include the following:

        1) Controls:

            a) Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
            b) Automatic restart on power failure.
            c) Safety lockout if any outdoor unit safety is open.
            d) A time delay control sequence provided through the fan coil board, thermostat, or controller.
            e) Automatic outdoor-fan motor protection.

        2) Safeties:

a) System diagnostics.
b) Compressor motor current and temperature overload protection.
c) High pressure relief.
d) Outdoor fan failure protection.

7. Electrical Requirements:

a. Unit electrical power shall be a single point connection.
b. Unit control voltage to the indoor-fan coil shall be 24 V.
c. All power and control wiring must be installed per NEC and all local building codes.

1) High- and low-voltage terminal block connections.

d. Accessories:

1) Low-Ambient Operation:

a) The control shall be capable of enabling unit operation and start-up with outdoor temperatures to 5 F.
b) Installation of kit shall not require changing the outdoor-fan motor.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence and Operations for HVAC Controls."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.
5. Automatic changeover from cooling to heating modes

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.

1. Minimum Insulation Thickness: 1 inch thick

a. Refer to 23 07 13 for metal jacketing for both refrigeration lines.

2. Provide precharged refrigerant lines that can be oriented to connect to the side or back of unit.

F. Unit shall be furnished with integral wall-mounting bracket and mounting hardware.

G. Drain Hose: For condensate.

H. Outdoor Unit Support System.

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

a. "Big Foot"; Rector Seal
b. Equivalent as approved.

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 Division 07. Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "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 REFRIGERANT PIPING SIZING

A. The unit manufacturer shall verify the final refrigeration pipe sizing process to insure conformance to specific unit requirements such as maximum lengths, refrigerant velocities, unloading considerations and proper oil return. This contractor shall provide refrigeration piping drawings from the field which details the way the piping will actually be installed.

3.3 REFRIGERANT PIPING ACCESSORIES

A. Install accessories in accordance with the manufacturer’s written instructions and recommendations.

3.4 EQUIPMENT SUPPORT SYSTEM

A. Where multiple condensers are required to be installed on a roof surface; condensers shall be mounted on a prefabricated condenser stand assembly which provides a professional appearance and is designed to spread the weight of the condensers evenly over the roof surface.

B. The condenser stand shall be mounted free standing on the roof surface in a convenient position to facilitate connection of the linesets to the condensers as well as access for maintenance.

C. Condenser stand shall be designed so that the feet and the supporting pads on which they rest do not penetrate the roofing membrane.

D. Condenser stand shall be of modular design to enable the cross members to be lineally adjusted during assembly to accept different configurations of condensers.

E. Condenser stand shall accommodate double decker cross members where space requirements mandate vertical stacking of condensers.

F. Condenser stand shall be fabricated from square steel tubing with a minimum wall thickness of 16 gauge.

G. For loads to a maximum of 660 lbs, cross members shall have a minimum cross section of 1.5” x 1.5“.

H. Condensers shall be secured to the cross bars with pressed steel clamps which shall be bolted to the cross members.

I. Steel clamps shall allow sufficient space for anti-vibration pads to be fitted under the feet of the condenser.

3.5 CONNECTIONS

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

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Ground equipment according to Division 26.

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

E. Division 26 contractor shall provide conduit for both the power and control wiring between indoor unit and outdoor unit.

F. Provide concrete splash blocks for exterior condensate piping discharge at grade level.

3.6 FIELD QUALITY CONTROL

A. 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.

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

C. Prepare test and inspection reports.

3.7 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.

B. Deliver unit wireless infrared remote controller to Owner with complete set of new batteries.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain split system air conditioning units.

END OF SECTION 23 81 26

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SECTION 23 82 39
UNIT 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 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For unit heaters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

A. Basis-of-Design Product: The design is based on the following:

1. Sterling HVAC Products; Div. of Mestek Technology Inc.

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. Airtherm; a Mestek Company.
2. McQuay International.
3. Modine Mfg. Co.
4. Rittling.
5. Sterling.
6. Vulcan.

C. Description: An assembly including casing, coil, fan, and motor in vertical discharge configuration with adjustable discharge louvers.

D. Comply with UL 2021.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

I. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.

J. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

K. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

L. Fan Motors: Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

M. Provide built-in fan delay switch.

N. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

2.2 CONTROLS:

A. Control devices and operational sequences are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls."

2.3 CAPACITIES AND CHARACTERISTICS:

A. Refer to Schedule on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 7 Section "Joint Sealants."

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers**.** Hanger rods and attachments to structure are specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 23 05 48.13 "Vibration Controls for HVAC."

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

F. Clean dust and debris from each unit as it is installed. Comb out damaged fins where bent or crushed before covering elements with enclosures.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 23 21 13 "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Comply with safety requirements in UL 1995.

D. Unless otherwise indicated, install union and ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Section 23 21 13 "Hydronic Piping."

E. Ground equipment according to Division 26.

F. Connect wiring according to Division 26.

3.4 FIELD QUALITY CONTROL

A. Contractor to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

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

3.5 ADJUSTING

A. Adjust initial temperature set points.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain unit heaters.

END OF SECTION 23 82 39

SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. Work to be performed under the sections of Divisions 26, 27 and 28 includes all labor, materials, and equipment required to install complete electrical systems as described in these specifications and as shown on the drawings. This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections.

B. Before submitting a bid, the Contractor shall examine the drawings and specifications, visit the work site, and be informed of local conditions, all federal, state and local ordinances, regulations and all other pertinent items which may affect cost, schedule, and completion of this project.

C. Drawings accompanying these specifications are a part of these specifications. Drawings are intended to show general arrangement, design, and extent of work and are diagrammatic. Drawings are not intended to show exact locations except where dimensions are shown. Any substantial differences existing between drawings and conditions in the field shall be submitted to the Engineer for consideration before proceeding with work. Electrical work is shown on plans using standard industry symbols.

D. Before ordering materials or doing work, the Contractor shall verify all measurements pertaining to work scope and assume installation responsibility for complete and fully functional electrical systems.

E. The electrical work included in all other divisions of this specification and related documents is the responsibility of the contractor performing the Division 26 and 28 work unless specifically noted otherwise.

1.3 REFERENCED STANDARDS

A. Abbreviations of standards organizations referenced in this and other sections are as follows:

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
EPA	Environmental Protection Agency
ETL	Electrical Testing Laboratories, Inc.
IBC	International Building Code

IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
ISA	Instrument Society of America
NBS	National Bureau of Standards
NEC	National Electric Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
UL	Underwriters Laboratories Inc.

1.4 QUALITY ASSURANCE

A. Manufacturer references used herein are intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

B. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space and for obtaining the performance from the system into which these items are placed.

C. All materials shall be listed by and shall bear the label of an approved electrical testing laboratory. If none of the approved electrical testing laboratories has published standards for a particular item, then other national independent testing standards, subject to approval by the Engineer, shall apply and such items shall bear those labels. Where one of the approved electrical testing laboratories has an applicable system listing and label, the entire system shall be so labeled. The Contractor shall not modify new equipment in such a way as to nullify the Testing Laboratories label. All equipment and materials shall be used or installed in accordance with any instruction included in the listing by the laboratory.

1.5 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. BACnet: A networking communication protocol that complies with ASHRAE 135.

C. BAS: Building automation system.

D. CCT: Correlated color temperature.

E. CPT: Control power transformer.

F. CRI: Color-rendering index.

G. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

H. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

I. Duct Bank:Two or more ducts installed in parallel, with or without additional casing materials and or multiple duct bank.

J. ETFE: Ethylene tetrafluoroethylene.

K. EMI: Electromagnetic interference.

L. EMT: Electrical metallic tubing.

M. Ethernet: Local area network based on IEEE 802.3 standards.

N. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

O. FEP: Fluorinated ethylene propylene.

P. GFCI: Ground-Fault Circuit Interrupter.

Q. IBC: International Building Code.

R. ICC-ES: ICC-Evaluation Service.

S. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.

1. Horizontal Illuminance: Measurement in foot-candles (lux), on a horizontal surface 30 inches (914 mm) above ground unless otherwise indicated.
2. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.
3. Vertical Illuminance: Measurement in foot-candles (lux), in two directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.

T. IMC: Intermediate metal conduit.

U. Inominal: Nominal discharge current.

V. Interruptible: As used in the Section Text, an off-line, passive-standby or line-interactive, inverter-only unit, with an intentional interruption of power to the load until an internal transfer switch picks up and transfers the load to the unit's inverter and internal battery source on loss of the "normal" source, and then retransfers to the "normal" source when it is restored. Transfer time can be "slow" (up to approximately 1 second) or "fast" (2-4 ms or 40-50 ms, depending on manufacturer).

W. I/O: Input/output.

X. IP Code: Required ingress protection to comply with IEC 60529.

Y. Jacket: A continuous nonmetallic outer covering for conductors or cables.

Z. LCD: Liquid crystal display.

AA. LED: Light-emitting diode.

BB. LER: Luminaire efficacy rating.

CC. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

DD. Lumen: Measured output of lamp and luminaire, or both.

EE. Luminaire: Complete lighting fixture, including ballast housing if integral.

FF. MCCB: Molded-case circuit breaker.

GG. NC: Normally closed.

HH. NETA ATS: Acceptance Testing Specification.

II. NiCd: Nickel cadmium.

JJ. NO: Normally open.

KK. OCPD: Overcurrent protective device.

LL. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

MM. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

NN. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

OO. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

PP. RMC: Rigid metal conduit.

QQ. SCCR: Short-circuit current rating.

RR. Sheath: A continuous metallic covering for conductors or cables.

SS. SPDT: Single pole, double throw.

TT. Uninterruptible: As used in the Section Text, an on-line, double-conversion (rectifier/inverter) unit, with no interruption of power to the load on interruption and restoration of the "normal" source.

UU. UPS: Uninterrupted power supply.

VV. UTP: Unshielded twisted pair.

WW. VFC: Variable-frequency motor controller.

XX. VFD – Variable frequency drive or motor controller.

1.6 REGULATORY REQUIREMENTS

A. All work and materials are to conform in every detail to applicable rules and requirements of local codes and regulations, the National Electrical Code (NFPA 70), other applicable National Fire Protection Association codes, and current manufacturing standards (including NEMA) and any additional local modifications enacted by the Local Authority Having Jurisdiction. Contractor shall be responsible to verify what if any local modifications are in place or enacted by the Local Authority Having Jurisdiction.

B. All work shall be installed in accordance with NECA standards of installation.

C. All work shall conform where applicable to the Williams-Steiger Occupational Safety and Health Act of 1970 (OSHA), Part 1910, “Occupational Safety and Health Standards.” This shall include any local or state modifications enacted by the Authority having Jurisdiction.

1.7 TEMPORARY CONSTRUCTION POWER

A. Provide temporary lighting and construction power for the project. Pay the usage charges to the serving utility for electric service associated with temporary lighting and power for construction. Refer to Division 1 requirements

1.8 OMISSIONS

A. A. No later than ten (10) days before bid opening, the Contractor shall call to the attention of the Engineer any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.9 SUBMITTALS

A. Refer to Division 1 for Submittal requirements.

B. Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name or number, as indicated in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor for correction and resubmission. Failing to follow these instructions does not relieve the Contractor from the requirement of meeting the project schedule.

C. On request, the Contractor shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc. to clarify intent of construction or operations.

D. Submittals shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams of electrically powered equipment.

E. The submittals must be approved before fabrication.

1.10 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.

B. Prepare drawings showing proposed rearrangement of work to meet Project conditions, including changes to work specified in other Sections. Obtain written permission of Engineer before proceeding.

C. Tools, materials, and equipment shall be confined to areas designated by the Owner.

1.11 WORK SEQUENCE AND SCHEDULING

A. See the General Conditions of the Contract, Scheduling and Coordination of Work, and Time for Completion of the Project, and General Requirements, Mutual Responsibility for additional requirements.

1.12 WORK BY OTHER TRADES

A. Every attempt has been made to indicate in this trade's specifications and drawings all work required of this Contractor. However, there may be additional specific paragraphs in other trade specifications and addenda, and additional notes on drawings for other trades which pertain to this Trade's work, and thus those additional requirements are hereby made a part of these specifications and drawings.

B. Electrical details on drawings for equipment to be provided by others is based on preliminary design data only. This Contractor shall lay out the electrical work and shall be responsible for its correctness to match equipment actually provided by others.

1.13 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Refer to Division 1, General Requirements, Operating and Maintenance Instructions for additional requirements.

1.14 TRAINING

A. Instruct Owner’s personnel in the proper operation and maintenance of systems and equipment provided as part of this project; video record all training sessions. Use the Operating and Maintenance manuals during this instruction. Demonstrate startup and shutdown procedures for all equipment. All training to be during normal working hours.

B. The requirement for recording training sessions may be deleted on some projects but not the requirement for the training itself.

C. Refer to other sections in Divisions 26 and 28 for specific section and equipment training requirements.

1.15 RECORD DRAWINGS

A. Contractor shall provide drawings to document as-built conditions per Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Reference applicable sections within Divisions 26, 27 and 28.

PART 3 - EXECUTION

3.1 WORK INCLUDED

A. The scope of work shall include all work, including all labor, materials and equipment, testing required to install a complete electrical system as indicated in the project Manual. The Project Manual consists of the bidding documents, the contract, specifications, contract drawings and all subsequent addenda and modifications. The contractor shall furnish and install all necessary materials, apparatus and devices to complete the electrical equipment and systems installation herein specified, except such parts as are specifically exempted herein.

B. All work items shown on the drawings is within the scope of work and shall be provided as indicated. Only items that are clearly indicated as being provided by others or under a separate contract shall be out of scope.

C. In general, the specifications indicate the requirements and quality for products required and the executions for those products. Only items that are clearly indicated as being provided by others or under a separate contract shall be out of scope.

D. If there is any discrepancy between the drawings and the specifications, it is the contractor’s responsibility to notify the Engineer for resolution, prior to procuring equipment or starting work.

E. Coordinate and verify all equipment being supplied by equipment supplier and other trades. Verify equipment size, motor HP, dimensions, locations, etc. as all are subject to change.

F. Contractor shall verify all door swings and the location of all cabinets, diffusers, HVAC, plumping, process and building equipment before installing electrical equipment, fixtures, outlets and conduit.

G. The Contractor shall provide all plywood backboards and supports for all electrical equipment as indicated on the drawings and as required or specified.

H. All permits and inspection fees required to complete the work shall be paid for by the Contractor unless noted otherwise.

I. All electrical equipment and fixtures shall be installed in complete accordance with the manufacturers' recommendations.

J. Contractor shall provide all motor connections as shown on the drawings and as specified herein.

K. Procure all applicable permits and licenses.

L. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

M. Electrical Contractor to pay all charges for permits or licenses.

N. Pay all fees and taxes imposed by State, Municipal, and other regulatory bodies.

O. Pay all charges arising out of required inspections by an authorized body.

P. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

Q. Where applicable, all fixtures, equipment and materials shall be listed by Underwriter's Laboratories, Inc. or a nationally recognized testing organization.

3.2 CONCRETE

A. All concrete work required for the proper installation of electrical equipment including transformer, switchgear and motor control center pads and other equipment pads shall be provided by the Contractor and shall conform to specifications in Division 3.

B. Consult with Electric Utility to verify service information specified herein and shown on drawings before submitting bid.

3.3 PERMITS, FEES, TAXES, INSPECTIONS

A. Procure all applicable permits and licenses.

B. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

C. Electrical Contractor to pay all charges for permits or licenses.

D. Pay all fees and taxes imposed by State, Municipal, and other regulatory bodies.

E. Pay all charges arising out of required inspections by an authorized body.

F. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

G. Where applicable, all fixtures, equipment and materials shall be listed by Underwriter's Laboratories, Inc. or a nationally recognized testing organization.

3.4 BUILDING ACCESS

A. Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this

contractor, restore any opening to its original condition after the apparatus has been brought into the building.

3.5 EQUIPMENT ACCESS

A. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Where access is required in plaster or drywall walls or ceilings, furnish the access doors to the General Contractor.

3.6 COORDINATION

A. The Contractor shall cooperate with other trades and the Owner's construction representative in locating work in a proper manner. Should it be necessary to raise or lower or move longitudinally any part of the electrical work to better fit the general installation, such work shall be done at no extra cost, provided such decision is reached prior to actual installation. The Contractor shall check location of electrical outlets with respect to other installations before installing.

B. The Contractor shall verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, light fixtures, panelboards, devices, etc. and recessed or semi-recessed heating units installed in/on architectural surfaces.

C. Coordinate all work with other trades prior to installation. Any installed work that is not coordinated and that interferes with another trades work shall be removed or relocated at the installing contractor's expense.

3.7 HOUSEKEEPING AND CLEAN UP

A. Refer to Division 1, General Requirements, and Cleaning for additional requirements.

B. The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, the Contractor shall remove all tools, excess material and equipment, etc., from the site.

END OF SECTION 26 05 00

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SECTION 26 05 02
ELECTRICAL DEMOLITION AND ALTERATION

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. Section 26 05 00 “Common Work Results for Electrical.”

C. NFPA 70 – National Electrical Code.

1.2 COORDINATION

A. Coordinate sequencing with Owner and other Contractors. Coordinate scope of work with all other Contractors and the Owner at the project site. Schedule removal of equipment and electrical service to avoid conflicts.

1.3 SUMMARY

A. Electrical Demolition

B. The drawings are intended to indicate the scope of work required and do not indicate every box, conduit, or wire that must be removed. The Contractor shall visit the site prior to submitting a bid and verify existing conditions.

1.4 CONTINUITY OF EXISTING SERVICES AND SYSTEMS

A. No outages shall be permitted on existing systems except at the time and during the interval specified by the Owner. The Owner may require written approval. Any outage must be scheduled when the interruption causes the least interference with normal Owner schedules and business routines. No extra costs will be paid to the Contractor for such outages which must occur outside of regular weekly working hours.

B. This Contractor shall restore any circuit interrupted as a result of this work to proper operation as soon as possible. Note that facility operations are on a seven-day week schedule.

C. Prior to demolition or alteration of structures, the following shall be accomplished:

1. Owner release of structure.
2. Disconnection of electrical power to utilization equipment and circuits removed or affected by demolition work.
3. Electrical services rerouted or shut off outside area of demolition.
4. Survey and record condition of existing facilities to remain in place that may be affected by demolition operations. After demolition operations are completed, survey conditions again and restores existing facilities to their predemolition condition.

5. Notify utilities prior to razing operations to permit them to disconnect and remove or relocate equipment that served existing facilities.
6. Contractor shall notify Architect/Engineer of existing code violations observed during the course of performing his work. If corrective action needs to be taken that changes the scope of the work, corrective action to proceed only after approved by Architect/Engineer.
7. Provide temporary wiring and connections to maintain existing systems in service during construction. Assume all equipment and systems must remain operational unless specifically noted otherwise on drawings.
8. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Obtain permission and no fewer than seven days in advance of proposed interruption of Fire Alarm System before partially or completely disabling systems. Minimize outage duration. If required, make temporary connections to maintain service in areas adjacent to work area. . Do not proceed with interruption without Owner's written permission.
9. Existing Wash Bay and Vacuum Systems: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission no fewer than seven days in advance of proposed interruption of existing Wash Bay and Vacuum System before partially or completely disabling systems. Minimize outage duration. If required, make temporary connections to maintain service in areas adjacent to work area. Do not proceed with interruption without Owner's written permission.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work as specified in the individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that abandoned wiring and equipment serve only abandoned equipment or facilities. Extend conduit and wire to facilities and equipment that will remain in operation following demolition. Extension of conduit and wire to equipment shall be compatible with the surrounding area.

3.2 PREPARATION

A. Where walls, ceilings, structures, etc., are indicated as being renovated and/or removed on general drawings, the Contractor shall be responsible for the removal of all electrical equipment, devices, fixtures, raceways, wiring, systems, etc., from the removed area.

B. Where ceilings, walls, structures, etc., are temporarily removed and replaced by others, this Contractor shall be responsible for the removal, storage, and replacement of equipment, devices, fixtures, raceways, wiring, systems, etc.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed. Patch openings created from removal of devices to match surrounding finishes.

B. Repair adjacent construction and finishes damaged during demolition and extension work. Patch openings to match existing surrounding finishes.

C. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

D. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified. This includes the extension of the circuit from the last active device to the next device in the system to be activated.

E. Equipment removal in certain locations may require the installation of a junction box to reconnect circuits that remain in operation. Extend conduit and wiring as required to maintain power to remaining equipment.

F. Contractor shall remove and install all ceiling tiles as required for the execution of electrical work that is outside the contract limits of construction. Contractor shall replace ceiling tiles with identical material where damaged by this Contractor.

G. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

H. Ballasts in light fixtures installed prior to 1980 shall be incinerated in EPA approved incinerator or disposed of in EPA certified containers and deposited in an EPA landfill certified for PCB disposal or recycled by permitted ballast recycler. Punctured or leaking ballasts must be disposed of according to Federal Regulations under the Toxic Substance Control Act. Provide Owner and Architect/Engineer with a Certificate of Destruction to verify proper disposal.

I. HID and fluorescent lamps, determined by the Toxicity Characteristic Leachate procedure (TCLP), to be hazardous waste shall be disposed of in a permitted hazardous waste disposal facility or by a permitted lamp recycler.

J. Floor slabs may contain conduit systems. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This includes x-ray or similar non-destructive means.

K. Contractor is responsible for all costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.4 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment that remain or are to be reused.

B. Panelboards: Within the project scope. Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

C. Luminaries: Remove existing luminaires for cleaning. Use mild detergent to clean all exteriors and interior surface, rinse with clean water and wipe dry. Replace lamps, ballasts, and broken electrical parts. Replacement parts shall match specified components for new fixtures of same type when applicable.

D. Electrical items (i.e., lighting fixtures, panelboard motor controllers, disconnects, switches, conduit, wire, etc.) Removed and not relocated remain the property of the owner. The contractor shall dispose of material the owner does not want.

3.5 ASBESTOS REMOVAL

A. If this Contractor shall discover the presence of asbestos material he shall cease work immediately and notify Owner architect and Engineer of condition.

3.6 INSTALLATION

A. Install relocated materials and equipment under the provisions of Division 26 Specifications.

END OF SECTION 26 05 02

SECTION 26 05 19
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 other 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.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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:

1. Alpha Wire.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable Technologies Corporation.
5. Southwire Incorporated.

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. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for armored cable, Type AC with ground wire.

E. Conductor sizes shown on drawings are based on 75 Degree C copper.

F. All conductors shall be rated 600 volts.

G. Branch circuit wire sizes not shown on the drawings shall be #12 AWG minimum.

H. All emergency system wiring shall be installed in raceways separate from other systems.

2.2 CONNECTORS AND SPLICES

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

1. AFC Cable Systems, Inc.
2. Gardner Bender.
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. Ilsco; a branch of Bardes Corporation.
6. NSi Industries LLC.
7. O-Z/Gedney; a brand of the EGS Electrical Group.
8. Thomas and Betts Corp.
9. 3M; Electrical Markets Division.
10. Tyco Electronics.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

1. Split Bolt Connectors: Not acceptable.
2. Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment pads or terminals. Not approved for splicing.
3. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.
4. All wire connectors used in underground or exterior pull boxes shall be gel filled twist connectors or a connector designed for damp and wet locations.
5. Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.
6. Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic copper tubing; internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps.

2.3 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.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATIONAND WIRING METHODS

A. Exposed Feeders: Type THHN-THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN-2, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade: Type THHN-THWN-2, single conductors in raceway.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade: Type THHN-THWN-2, single conductors in raceway.

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 FEEDERS AND BRANCH CIRCUITS

A. Feeder and branch circuit routing is shown diagrammatically on the drawings and is approximate unless dimensioned. Route feeders and branch circuits as required to meet project conditions.

B. All 120- and 277-volt branch circuits shall have a dedicated neutral conductor. The neutral conductor shall be considered current-carrying conductor for wire derating. The use of multi-wire branch circuits with a common neutral is not permitted.

C. All power wiring shall be installed in conduit unless specifically indicated otherwise.

D. Conceal feeders and branch circuits in finished walls, ceilings, and floors, unless otherwise indicated.

E. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

F. 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.

G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

H. Install exposed feeders and branch circuits parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

I. Support feeders and branch circuits according to Division 26 Section "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.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 05 53 "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.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

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 Division 7.

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 all power and equipment branch circuit conductors for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Perform insulation-resistance test, with respect to ground and adjacent conductors, on each conductor of power feeders 100 amperes or greater. Applied potential shall be 1000 volts dc for 600 volt rated cable. Test duration shall be one minute. Insulating-resistance values should not be less than 50 megohms.
4. Any conductors that fail the above-mentioned tests shall be replaced and those new conductors shall be tested and meet the requirements mentioned above.

B. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 26 05 19

SECTION 26 05 23
CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Low-voltage control cabling.
2. Control-circuit conductors.
3. Identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

PART 2 - PRODUCTS

2.1 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.

2.2 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.4 CONTROL-CIRCUIT CONDUCTORS

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

1. Encore Wire Corporation.
2. General Cable Technologies Corporation.
3. Southwire Company.

B. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

C. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables according to TIA-568-C.2.

C. Factory test optical-fiber cables according to TIA-568-C.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2½ inches deep.
2. Flexible metal conduit shall not be used.

B. Install manufactured conduit sweeps and long-radius elbows if possible.

C. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced.

5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lay on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

3.3 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.

3.5 FIRESTOPPING

A. Comply with requirements in Section 07 84 13 "Penetration and Joint Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.6 GROUNDING

A. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.8 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. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 26 05 23

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SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

1.2 QUALITY ASSURANCE

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. ILSCO.
4. O-Z/Gedney; A Brand of the EGS Electrical Group.

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:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Telecommunications Main Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

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.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

3.2 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. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. 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.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

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SECTION 26 05 29
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 other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 INFORMATIONAL SUBMITTALS

A. No submittal required.

1.4 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

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

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. ERICO International Corporation.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut; Tyco International, Ltd.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Channel Dimensions: Selected for applicable load criteria.

B. Supports installed in in the vehicle wash bay areas shall be schedule 40 ASTM type 316 stainless steel with ASTM type 316 stainless steel welded end-caps and end plates and polished finish. Stainless steel screws, nuts and bolts shall be ASTM type 316N2-33.

C. Stainless steel supports, fittings and hardware shall be ASTM type 316 with polished finish. Stainless steel screws, nuts, and bolts shall be ASTM type 316N2-33.

D. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

E. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used. Plastic type expansion anchors are unacceptable.

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

        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be ¼ inch (6 mm) in diameter.

C. 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.

D. All supports installed outside, exposed to the weather, or inside in wet or damp areas shall utilize corrosion resistant supports, fittings, hardware, conduit clamps and all accessories.

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, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in 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. All electrical fixtures, devices, and equipment shall be securely mounted to building structure and shall not depend upon ceiling or wall surfaces for their support. They shall be incapable of being rotated or displaced.

E. Do not fasten supports to piping, ductwork, mechanical equipment, cable tray, conduit, or any other surface not a part of the building structure or other structural surface.

F. 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. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction

boxes, transformers, and other devices on slotted-channel racks attached to substrate.

G. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

H. Do not drill or weld structural steel members unless approved by Engineer.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

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 minimum dry film thickness of 2.0 mils (0.05 mm).

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

END OF SECTION 26 05 29

SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures, and cabinets.

B. Related Requirements:

1. Division 7 for firestopping at conduit and box entrances.

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

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

    a. Republic Conduit.
    b. Southwire Company.
    c. Western Tube and Conduit Corporation.
    d. Wheatland Tube Company.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. RMC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. FMC: Comply with UL 1; zinc-coated steel.

7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203.
5. Fittings for EMT:

    a. Material: Steel.
    b. Type: Setscrew.

6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651 for PVC and type XJ for steel, rated for environmental conditions where installed, and including flexible external bonding jumper.
7. Joint Compound for IMC and RMC Approved, as defined in NFPA, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

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

    a. CANTEX, Inc.
    b. Electri-Flex Company.
    c. Kraloy
    d. Lamson & Sessions; Carlon Electrical Products.
    e. Thomas & Betts Corporation; A Member of the ABB Group.

2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
3. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:

1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
3. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Flanged-and-gasketed type unless otherwise indicated.

E. Finish: ANSI 61 Gray for steel wireways.

2.4 BOXES, ENCLOSURES, AND CABINETS

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

1. Crouse-Hinds, an Eaton business.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. FSR Inc.
5. Hoffman; a brand of Pentair Equipment Protection.
6. Hubbell Incorporated.
7. Kraloy.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. RACO; Hubbell.
10. Thomas & Betts Corporation; A Member of the ABB Group.
11. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, deep-type, ferrous alloy, Type FD, with gasketed cover, threaded hubs.

E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

F. Sheet Metal Pull and Junction Boxes: NEMA OS 1, galvanized steel.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover and stainless-steel cover screws.

1. Flanged Type boxes shall be used where installed flush in wall.

H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

J. Telecommunications and Security Device Box Dimensions: 4 11/16 inches square by 2-1/8 inches deep unless noted otherwise.

K. Gangable boxes are prohibited.

L. Accessories

1. Fire rated Moldable pads: UL #9700, moldable sheet putty at required thickness on all five sides of back boxes. Acceptable manufacturers: Kinetics Noise Control, IsoBacker Pad, SSP Putty and Pads or equal.
2. Sound Barrier Insulation Pads: Mastic, non-harding, sheet material, and minimum 1/8" thickness applied to all five sides of the back boxes. Acceptable manufacturers: Kinetics Noise Control, SealTight Backer Pad and L.H. Dottie Co., #68 or equal.

PART 3 - EXECUTION

3.1 RACEWAY SIZING

A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to NEC. (Latest Edition). Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the National Electrical Code (to include enlarged conductor's due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

B. Minimum (Unless noted otherwise) Raceway Size 3/4-inch (21 mm) trade size.

C. Minimum Raceway Size Telecommunication and Security Conduit: 1 inch, unless noted otherwise in documents.

D. Minimum Raceway Size Control Conduit: 3/4-inch, unless noted otherwise in documents.

E. Minimum Raceway Size; Below Grade 5'-0" or less from Building Foundation: 3/4- inch, unless noted otherwise in documents.

F. Minimum Raceway Size; Below Grade more than 5'-0" from Building Foundation: 3/4-inch, unless noted otherwise in documents.

G. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: RMC.
2. Concealed Conduit, Aboveground: RMC.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: RMC. Raceway locations include the following:

    a. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    b. Electric Bus Charging Stations
    c. Vehicle Maintenance Bays and Storage
    d. Bus Wash Bays.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Flexible Metal Conduit (FMC) ¾ inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire. Flexible metal conduit may be a manufactured, UL listed 3/8-inch flexible metal conduit and fittings with #14 AWG THHN conductors and an insulated ground wire. Maximum length of 3/8 inch FMC shall be six (6) feet.
7. Damp or Wet Locations: RMC.
8. Damp or Wet Locations and subject to Physical Damage: RMC,
9. Hazardous Locations: All raceways installed in hazardous locations shall be suitable for locations as defined in the NEC Article 500.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use setscrew, fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

3.3 BOXES AND ENCLOSURES APPLICATIONS

A. Boxes and Enclosures:

1. Dirty locations: NEMA 250, Type 12, powder coated steel.
2. Vehicle bus wash area: NEMA 250 Type 4X, Plastic Coated Rigid Steel PVC.
3. Hazardous Locations: All boxes and enclosures installed in hazardous locations shall be suitable for locations as defined by NEC Article 500.

3.4 INSTALLATION

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. In general, conduits shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

D. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, rough through jack with pitch pocket. Coordinate roof penetrations with others.

E. Conduit runs shall be routed as shown on the large-scale drawings. Conduit routing on drawings scaled ¼" = 1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Contractor based on information provided in the contract documents, in accordance with manufacturer's written instructions, applicable coded, NECA 1 and NECA 101 and coordinated with other contractors.

F. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

G. Do not fasten conduits onto the bottom side of a metal deck roof.

H. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

I. Complete raceway installation before starting conductor installation.

J. Install temporary closures to prevent foreign matter from entering raceways.

K. Unused openings in boxes and fittings shall be plugged with suitable devices rated for the proper environment.

L. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.

M. Arrange stub-ups so curved portions of bends are not visible above finished slab. Where rigid non-metallic conduit (RNC) conduit is used below grade, in slab, below slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits the earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.

N. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

O. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inchesof changes in direction and within 12 inches of enclosures to which attached to.

P. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

Q. Conceal conduit within finished walls, and ceilings, unless otherwise indicated. Install conduits parallel or perpendicular to building lines. Conduit runs installed above suspended ceilings shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit supports.

R. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.

1. Run parallel or banked raceways together on common supports.
2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

S. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

T. Conduit shall not be routed under floor slab unless specifically noted on drawings.

U. Contractor shall be responsible for all openings required in masonry or exterior walls under this division. A qualified mason at the expense of this contractor shall repair all openings to match existing conditions.

V. Telecommunication Conduits:

1. Conduits that protrude through the structural floor shall be installed 1 to 3” above finished floor (AFF).
2. Conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4-inches below ceiling and as close to the wall as possible
3. Conduits that are below grade and enter the building shall terminate a minimum of 4-inches above finished floor (AFF) and as close to the wall as possible.
4. Condit terminations shall have nylon bushings installed on each end of every conduit run.
5. Telecommunication conduits shall have no more than two (2) 90 degree bends between pull points and contain no continuous sections longer than 100 feet. Insert pull points or pull boxes for conduits exceeding 100 feet in length..A third bend is acceptable if: The total run is no longer than (33) feet.
6. The conduit size is increased to the next trade size.

7. Telecommunications pull boxes shall not be used in lieu of a bend. Align conduits that enter into the pull box from the opposite ends with each other. Pull box size shall be twelve (12) times the diameter of the largest conduit. Slip sleeves or gutters can be used in place of a pull box.
8. Conduit bend radius shall be six (6) times the diameter for conduits under 2-inches and ten (10) times the diameter for conduits over 2-inches.

W. All raceway systems installed in Wash Bay area shall utilize wet location rated conduit, fittings and connection devices. All hardware and supports shall be corrosion resistant.

3.5 CONDUIT TERMINATIONS

A. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

B. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

C. Join raceways with fittings designed and approved for that purpose and make joints tight.

D. When raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.

E. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

F. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

G. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus ¼ turn more.

H. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

I. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

K. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel

box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

L. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Where otherwise required by NFPA 70.

M. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

N. Expansion fittings shall be installed across expansion joints in structures and concrete construction where such joints are shown on the architectural and structural drawings.

O. Expansion-Joint Fittings:

1. Install in each run of above ground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

P. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC

may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

Q. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

3.6 BOX INSTALLATION

A. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

B. Recessed Boxes in Masonry Walls: Saw-cut opening for box in corner of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

C. Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and provide 18 inch by 24 inch access doors.

D. No back to back outlet boxes shall be installed.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.
2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated stud walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches of the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads on all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

E. Electrical box locations shown on drawings are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

F. No outlet shall be located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.

G. It shall be the Contractor's responsibility to study drawings pertaining to other trades, to discuss location of outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.

H. The proper location of each outlet is considered a part of this contract and no additional compensation will be paid to the Contractor for moving outlets which were improperly located.

I. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

J. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

K. Locate boxes so that cover or plate will not span different building finishes.

L. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

M. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

N. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 7.

3.9 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33

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SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS 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. Metal conduits and fittings, including RMC. Rigid nonmetallic duct.
2. Flexible nonmetallic duct.

1.3 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Shop Drawings:

1. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. RMC: Comply with ANSI C80.1 and UL 6.

B. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

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

1. CANTEX INC.
2. Lamson & Sessions.
3. Approved Equal

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct entrances into boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

B. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 20 00 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work.

D. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

E. Install duct according to NEMA TCB 2.

F. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.

G. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

H. Building Wall Penetrations: Make a transition from underground duct to RMC at least 5-feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to- RMC transition. Install RMC penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

I. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

J. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.

1. Width: Excavate trench 3 inches wider than duct on each side.

K. Direct-Buried Duct:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 20 00 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
4. Set elevation of bottom of duct bank below frost line.
5. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
6. Install manufactured RMC elbows for stub-ups, at building entrances, and at changes of direction in duct.

a. Couple RNC duct to RMC with adapters designed for this purpose and encase coupling with 3 inches of concrete.
b. Stub-ups to Outdoor Equipment: Extend concrete-encased RMC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.

c. Stub-ups to Indoor Equipment: Extend concrete-encased RMC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

7. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 20 00 "Earth Moving" for installation of backfill materials.

a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct.,
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus ¼ inch. If obstructions are indicated, remove obstructions and retest.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.5 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 26 05 43

SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Grout.
3. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

2.2 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.3 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall, so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide ¼-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 FIELD QUALITY CONTROL

A. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work. Replace sleeve and sleeve-seals that are damaged or faulty.

END OF SECTION 26 05 44

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SECTION 26 05 53
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 other 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. Warning labels and signs.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

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.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

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

C. Coordinate installation of identifying devices with location of access panels and doors.

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

PART 2 - PRODUCTS

2.1 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

2.2 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.

2.3 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs for interior use:

1. Pre-printed aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.
2. ¼-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs for exterior use:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. ¼-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.4 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.5 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.6 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black except where used for color-coding.

B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select 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 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.

G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, 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 service feeder and branch-circuit conductors.

a. Color shall be factory applied.
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 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.

B. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

C. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

D. Control-Circuit Conductor Termination Identification: For identification at terminations provide self-adhesive vinyl labels with the conductor designation.

E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. 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 the Operation and Maintenance Manual.

G. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

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 transfer switches.
    b. Controls with external control power connections.

H. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

I. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-

inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless provided with self-adhesive means of attachment, fasten labels 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 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. Enclosed switches.
f. Enclosed circuit breakers.
g. Enclosed controllers.
h. Variable-speed controllers.
i. Push-button stations.
j. Contactors.
k. Remote-controlled switches, dimmer modules, and control devices.
l. Battery-inverter units.
m. Monitoring and control equipment.

END OF SECTION 26 05 53

SECTION 26 09 23
LIGHTING CONTROL DEVICES

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. Standalone daylight-harvesting dimming controls.
2. Indoor occupancy and vacancy sensors.
3. Switchbox-mounted occupancy and vacancy sensors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

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

a. Faulty operation of lighting control devices.

2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Eaton Inc.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. NSi Industries LLC.

B. Description: Solid state, with SPST dry contacts rated for 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Mounting: Fixed base for conduit mounting and capable of being wall mounted.
5. Failure Mode: Luminaire stays ON.

C. Description: Solid state; one set of NO dry contacts rated for 24 V ac at 1 A, to operate connected load, complying with UL 773, and compatible with lighting control panelboard.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Mounting: Fixed base for conduit mounting and capable of being wall mounted.
5. Failure Mode: Luminaire stays ON.
6. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

    a. LED status lights to indicate load status.
    b. Plenum rated.

2.2 DAYLIGHT-HARVESTING DIMMING CONTROLS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. System programming is done via push button.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
3. Light-Level Sensor Set-Point Adjustment Range: 0 to 200 fc.

E. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

1. LED status lights to indicate load status.
2. Plenum rated.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

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

1. Cooper Industries, Inc.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Lutron Electronics Co., Inc.
4. Sensor Switch, Inc.

B. General Requirements for Sensors:

1. Refer to Occupancy/Vacancy/Photo Sensor Schedule on drawings for voltage, coverage area & pattern, mounting type and technology information.
2. Separate power pack.
3. Hardwired connection to switch.
4. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. 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 shall 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.

6. Sensor Output: Sensor is powered from the power pack.
7. Power: Line voltage.
8. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
9. Mounting:

   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

10. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
11. Bypass Switch: Override the "on" function in case of sensor failure.
12. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: 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.

2.4 SWITCHBOX-MOUNTED OCCUPANCY AND VACANCY SENSORS

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

1. Cooper Industries, Inc.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Lutron Electronics Co., Inc.
4. Sensor Switch, Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.

1. Refer to Occupancy/Vacancy/Photo Sensor Schedule on drawings for voltage, coverage area & pattern, mounting type and technology information.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. 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.
4. 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.
5. Combination Sensor: Unless otherwise indicated, sensor shall 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.
6. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
7. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V,

C. Wall-Switch Sensor, Standard Coverage:

1. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
2. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
3. Color: Ivory.
4. Faceplate: Color matched to switch.

D. Wall-Switch Sensor, Wide Coverage:

1. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
2. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
3. Color: Ivory.
4. Faceplate: Color matched to switch.

2.5 EMERGENCY SHUNT RELAY

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

1. Lighting Control and Design.
2. Wattstopper.

B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 277 V.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. 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.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

D. All lighting control units shall be installed in an appropriate enclosure for the type of environment encountered. No exposed wiring shall be permitted inside of the building or pedestal mounted enclosure in which this equipment is installed.

E. Photoelectric switches shall be oriented to the north or east with only eye visible from the exterior of the enclosure.

F. The location and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The contractor shall provide additional sensors if required to properly and completely cover the respective room.

3.3 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is ½ inch.

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.

D. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 26 09 23

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SECTION 26 09 43.23
RELAY-BASED LIGHTING CONTROLS

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: Lighting control panels using mechanically held relays for switching.

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 control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.

B. Shop Drawings: For each relay panel and related equipment.

1. Detail enclosure types and details for types other than NEMA 250, Type 1.
2. Detail wiring partition configuration, current, and voltage ratings.
3. Short-circuit current rating of relays.
4. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in Section 23 09 24 "Direct Digital Control System for HVAC."

1. Show interconnecting signal and control wiring, and interface devices that prove compatibility of inputs and outputs.
2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the network protocol.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting controls 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. Lighting Control Relays: Equal to 10 percent of amount installed, but no fewer than 2.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panels for installation according to NECA 407.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multipreset modular dimming controls that fail in materials or workmanship within specified warranty period.

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

a. Damage from transient voltage surges.

2. Warranty Period: Cost to repair or replace any parts for five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, shall open or close one or more lighting control relays in the lighting control panels. Any combination of inputs shall be programmable to any number of control relays.

B. Interface with HVAC DDC System: Hardware and software shall interface with HVAC DDC system to monitor, control, display, and record data for use in processing reports. Comply with requirements in Section 23 09 24 "Direct Digital Control System for HVAC."

1. Hardwired Points:

a. Monitoring: On-off status.

b. Control: On-off operation.

2. Communication Interface: Comply with ASHRAE 135. The communication interface shall enable the HVAC DDC system operator to remotely control and monitor lighting from a HVAC DDC system operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the HVAC DDC system. Comply with requirements in Section 23 09 24 "Direct Digital Control System for HVAC."

C. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.

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 47 CFR 15, Subparts A and B, for Class A digital devices.

F. Comply with UL 916.

2.2 LIGHTING CONTROL RELAY PANELS

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

1. Acuity Brands Lighting, Inc.; Lithonia Lighting brand.
2. Intelligent Lighting Controls.
3. Lutron Electronics Co., Inc.
4. NexLight; part of the Northport Engineering Group.
5. Watt Stopper/Legrand.

B. Description: Standalone lighting control panel using mechanically latched relays to control lighting and appliances.

C. Lighting Control Panel:

1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
2. A vertical barrier separating branch circuits from control wiring.

D. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.

1. Timing Unit:

a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
c. Four independent schedules, each having 24 time periods.
d. Schedule periods settable to the minute.

e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
f. 10 special date periods.

2. Sequencing Control with Override:

a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
b. Sequencing control shall operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
c. Override control shall allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
d. Override control "blink warning" shall warn occupants approximately 15 minutes before actuating the off sequence.

3. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation, including accurate time of day and date.

E. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating shall be not less than 5 kA. Control shall be three-wire, 24-V ac.

F. Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, low-voltage inputs, field-installed occupancy sensors, and photo sensors.

G. Operator Interface:

1. Integral alphanumeric keypad and digital display, and intuitive drop-down menus to assist in programming.
2. Log and display relay on-time.
3. Connect relays to one or more time and sequencing schemes.

2.3 MANUAL SWITCHES AND PLATES

A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.

1. Match color and style specified in Section 26 27 26 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

B. Wall Plates: Single and multigang plates as specified in Section 26 27 26 "Wiring Devices."

C. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.4 FIELD-MOUNTED SIGNAL SOURCES

A. Daylight Harvesting Switching Controls: Comply with Section 26 09 23 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.

2.5 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panels according to NECA 407.

B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 PANEL INSTALLATION

A. Comply with NECA 1.

B. Install panels and accessories according to NECA 407.

C. Mount top of trim 90 inches above finished floor unless otherwise indicated.

D. Mount panel cabinet plumb and rigid without distortion of box.

E. Install filler plates in unused spaces.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53 "Identification for Electrical Systems."

C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.

D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup check according to manufacturer's written instructions.
2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 26 09 43.23

SECTION 26 22 13
LOW-VOLTAGE DISTRIBUTION 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 with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

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.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
5. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton.
2. General Electric Company.
3. Hammond Power Solutions Inc.
4. Siemens Industry, Inc., Energy Management Division.
5. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified."

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

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 use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Grounded to enclosure.

C. Coils: Continuous windings except for taps.

1. Coil Material: Aluminum.

2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded.

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.
3. Wiring Compartment: Sized for conduit entry and wiring installation.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

F. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

G. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

1. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

H. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 50.01 to 150.00 kVA: 50 dBA for K-factors of 1, 4, and 9.

2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

C. 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.

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

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 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "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. Perform tests and inspections.

B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.

2. Electrical Tests:

    a. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

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.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 13

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SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 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. Component List.
8. Cable terminal sizes.
9. Break layout drawings with dimensions indicated and nameplate designations.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. Refer to Division 1 “Operation and Maintenance Data” for additional requirements.

1.5 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 and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NEMA PB 1.

1.8 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. Altitude: Not exceeding 1000 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 1000 feet.

1.9 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: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. 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.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush or Surface-mounted (as indicated on Panel Schedules), dead-front cabinets.

1. Rated for environmental conditions at installed location.

    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    b. Outdoor Locations: NEMA 250, Type 3R.
    c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

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: Steel and 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: Same finish as panels and trim.

F. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

    a. Plating shall run entire length of bus.
    b. 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.

G. 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. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Sub-feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

H. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: 20 percent.

I. 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. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 POWER PANELBOARDS

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Refer to Panel Schedule.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Refer to Panel Schedules.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. 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:

1. Eaton.
2. General Electric Company; GE Energy Management - Electrical Distribution.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by 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. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Sub-feed Circuit Breakers: Vertically mounted.
4. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Breaker handle indicates tripped status.
    c. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    d. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
    e. Multipole units enclosed in a single housing with a single handle.
    f. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

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: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

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.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Mount top of panelboard so that the top-most switch or circuit breaker is not higher than 78” (6’ – 6”) above finished floor or grade.

G. Mount panelboard cabinet plumb and rigid without distortion of box.

H. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

I. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

J. 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.

K. Install filler plates in unused spaces.

L. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

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 26 05 53 "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 26 05 53 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Panelboards will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

SECTION 26 27 26
WIRING DEVICES

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. Standard-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. Twist-locking receptacles.
4. Cord and plug sets.
5. Toggle switches, 120/277 V, 20 A.
6. Digital timer light switches.
7. Wall plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

2. Cord and Plug Sets: Match equipment requirements.

F. Device Color:

1. Wiring Devices Connected to Normal Power System: Gray unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Essential Electrical System: Red.

G. Wall Plate Color: For plastic covers, match device color.

H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

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

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Duplex Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.

C. Weather-Resistant Duplex Receptacle, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 GFCI RECEPTACLES, 125 V, 20 A

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

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Duplex GFCI Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: Non-feed through.

4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.4 TWIST-LOCKING RECEPTACLES

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

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Twist-Lock, Single Receptacles, 250 V, 20 A:

1. Configuration: NEMA WD 6, Configuration L6-20R.
2. Standards: Comply with UL 498.

2.5 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.6 TOGGLE SWITCHES, 120/277 V, 20 A

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

1. Hubbell Premise Wiring.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Single-Pole Switches, 120/277 V, 20 A:

1. Standards: Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 20 A:

1. Comply with UL 20 and FS W-S-896.

2.7 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 IDENTIFICATION

A. Comply with Section 26 05 53 "Identification for Electrical Systems."

B. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.3 FIELD QUALITY CONTROL

A. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions remove malfunctioning units and replace with new ones, and retest as specified above.

B. Wiring device will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 26 27 26

SECTION 26 28 13
FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches and enclosed controllers.

1.2 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than 3 of each size and type.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

1.4 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Tracor;Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Motor Branch Circuits: Class RK1, time delay.
2. Control Circuits: Class CC, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Fuses shall not be installed until equipment is ready to be energized.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13

SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Enclosures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details.
2. Current. horsepower, and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

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

C. Comply with NFPA 70.

1.4 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 1000 feet.

1.5 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. HD Switches:

1. UL Listed Short Circuit Rating: 200,000 symmetrical amperes when Class R or Class J fuses are used on switch sizes 30 to 600 amperes. The UL listed short circuit rating shall be 200,000 symmetrical amperes when Class L fuses are used on switch sizes 800 to 1200 amperes.
2. Switch Blades: Visible when the switch is OFF and the cover is open.
3. Lugs: Front removable and UL listed for 167 deg F conductors aluminum or copper conductors.
4. Fuse Pullers: 30 through 100 ampere switches shall be equipped with factory installed fuse pullers.
5. Arc Suppressors: Removable arc suppressors to facilitate easy access to line side lugs.
6. Switch Operating Mechanism: Quick-make, quick-break such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started.
7. Handle Position: At least 90° between OFF and ON positions to clearly distinguish and indicate handle position, “ON” and “OFF” positions shall be labeled.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NON-FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. HD Switches:

1. UL Listed Short Circuit Rating: 200,000 symmetrical amperes when Class R or Class J fuses are used on switch sizes 30 to 600 amperes. The UL listed short circuit rating shall be 200,000 symmetrical amperes when Class L fuses are used on switch sizes 800 to 1200 amperes.
2. Switch Blades: Visible when the switch is OFF, and the cover is open.
3. Lugs: Front removable and UL listed for 167 deg F conductors' aluminum or copper conductors.
4. Fuse Pullers: 30 through 100 ampere switches shall be equipped with factory installed fuse pullers. Arc Suppressors: Removable arc suppressors to facilitate easy access to line side lugs.
5. Switch Operating Mechanism: Quick-make, quick-break such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started.
6. Handle Position: At least 90° between OFF and ON positions to clearly distinguish and indicate handle position, "ON" and "OFF" positions shall be labeled.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location. Provide the following minimum requirements, unless noted otherwise on the drawings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Install fuses in fusible devices.

C. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

1. Label each enclosure with engraved metal or laminated-plastic nameplate.

B. Provide and install on the inside door of all fusible disconnect switches a typewritten copy with a transparent protective cover with the following information.

1. Fuse Amperage
2. Fuse Type
3. Fuse Class
4. Fuse Voltage Rating
5. Fuse Manufacturer
6. Unit or Circuit Protected by Fuse

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION 26 28 16

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SECTION 26 29 13
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.

B. Related Section:

1. Refer to the Electrical Equipment Wiring Schedule on drawings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

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

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.

1.4 MATERIALS MAINTENANCE 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. Fuses for Fused Switches: 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.

B. Fuse Pullers: Furnish one (1) fuse puller to Owner and placed in fuse cabinet.

1.5 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.

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. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces as defined on structural drawings.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 1000 feet.

1.8 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle action; marked to show whether unit is off or on.

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

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Siemens Energy & Automation, Inc.
    d. Square D; a brand of Schneider Electric.

2. Configuration: Non-reversing.
3. Surface mounting.
4. Red pilot light.

C. Magnetic Controllers: Full voltage, across the line, electrically held.

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

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Siemens Energy & Automation, Inc.
    d. Square D; a brand of Schneider Electric.

2. Configuration: Non-reversing.
3. Contactor Coils: Pressure-encapsulated type.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, 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 control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

6. Solid-State Overload Relay:

    a. Switch or dial selectable for motor running overload protection.
    b. Sensors in each phase.
    c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

D. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

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

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Siemens Energy & Automation, Inc.
    d. Square D; a brand of Schneider Electric.

2. Fusible Disconnecting Means:

    a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
    b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2.2 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.

2.3 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, type.

a. Push Buttons: Covered types; momentary as indicated.
b. Pilot Lights: LED types; colors as indicated; push to test.
c. Selector Switches: Rotary type.

B. Reversible N.C./N.O. auxiliary contact(s).

C. 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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

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

3.2 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Install fuses in each fusible-switch enclosed controller.

C. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13 "Fuses."

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Label each enclosure with engraved nameplate.
2. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Bundle, train, and support wiring in enclosures.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Test each motor for proper phase rotation.
5. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
6. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
7. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Enclosed controllers will be considered defective if they do not pass tests and inspections.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 26 29 13

SECTION 26 33 23
CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.

1.2 SUMMARY

A. Section includes the following central battery and power conversion equipment rated 600 V and less for emergency lighting:

1. Interruptible (fast-transfer) central battery equipment.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For each type and rating of central battery equipment unit.

1. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, shipping splits, and furnished options, specialties, and accessories.
2. Include plans, elevations, sections, and mounting details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, ventilation requirements, method of field assembly, components, and location and size of each field connection.
4. Include system one-line diagram, internal and interconnecting wiring; and diagrams for power, signal, and control wiring.
5. Include elevation, details, and legends of control and indication displays.
6. Include -circuit current (withstand) rating of unit.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For central battery equipment to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

    a. Manufacturer's written instructions for testing central battery equipment.
    b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
    c. Manufacturer's written instructions for selecting and setting field-adjustable controls and status and alarm points

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
3. Humidity: More than 95 percent (condensing).
4. Altitude: Exceeding 1000 feet.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:

a. Central Battery Equipment (excluding Batteries): Two (2) years.
b. Standard VRLA Batteries:

1) Full Warranty: One (1) year.
2) Pro Rata: Nine (9) years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Inverter:

1. Load Power Factor: 0.5 lead to 0.5 lag.
2. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.

2.2 INTERRUPTIBLE (FAST-TRANSFER) CENTRAL BATTERY EQUIPMENT

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

1. Cooper Industries, Inc.
2. Crucial Power Products.
3. Emergi-Lite; Thomas & Betts Corporation.
4. Myers Power Products, Inc.

B. General Requirements for Interruptible (Fast-Transfer) Central Battery Equipment:

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. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

C. Performance Requirements:

1. Fast-Transfer Central Battery Equipment: Line-interactive (on-line) system. Automatically sense loss of normal ac supply and use a solid-state static switch to transfer load. Transfer in 40-50 ms or less from normal supply to battery-inverter supply.
2. Automatic Operation:

    a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, bypassing inverter, with battery connected in parallel via rectifier/charger output.
    b. Abnormal Supply Conditions: If normal ac supply deviates from specified voltage, transfer switch operates, and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    c. If normal power fails, transfer switch operates, and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    d. If a fault occurs in system when being supplied by inverter and current flows in excess of the overload rating of inverter, inverter automatically protects itself against damage from overloads and short circuits by shutting down.
    e. When normal ac power is restored at input supply terminals of unit, controls automatically retransfer the load back to the normal ac supply, with a momentary loss of power to the load. Rectifier/charger then recharges battery.

f. If normal power failure is prolonged (more than 90 minutes), integral low-voltage battery protective circuit disconnects battery and prevents battery from damage due to deep discharge.
g. If battery becomes discharged, and when normal ac supply is again available, rectifier/charger recharges battery. When battery is fully charged, rectifier/charger automatically shifts to float-charge mode.
h. If battery is disconnected, and normal ac power is available, central battery equipment continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus, or minus 3 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F and not exceeding 86 deg F.
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F and not exceeding 158 deg F
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F and not exceeding 104 deg F.
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F and not exceeding 104 deg F
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet.
12. Off-Line Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

F. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

a. Normal power available.
b. Status of system.
c. Battery charging status.
d. On battery power.
e. System fault.
f. External fault.

2. 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.

a. Keypad: In addition to required programming and control keys, include the following:

1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:

1) Real-time clock with current time and date.
2) Tests and Events Logs: Record and store up to 25 tests and events.

a) Dates.
b) Times.
c) Durations.
d) Output voltage and currents.

3) Alarm Logs: Record and store up to 25 alarms.

a) Dates.
b) Times.
c) Alarm type.

4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:

a) Input and output voltage (V ac) and output current (A ac).
b) Battery voltage (V dc) and current (A ac).
c) Fault or alarming status (code).
d) Power output (VA).
e) Inverter load (W).
f) Ambient temperature (deg F).
g) System run time (cumulative days).
h) Inverter run time (cumulative minutes).

5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:

a) High/low battery charge voltage.
b) High/low input voltage.
c) Battery nearing low-voltage condition.
d) Battery low voltage.
e) High ambient temperature.
f) Inverter fault.
g) Output fault.

h) Output overload.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: 10 kA.

I. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 3 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 3 percent for 100 percent step-load changes.
b. Automatically regulate output frequency to within plus or minus .05 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Output Voltage Waveform: Sine wave with maximum 3 percent TDD throughout battery operating-voltage range, for 100 percent linear load.
d. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 16 seconds.
e. Load Power Factor: 0.5 lead to 0.5 lag.
f. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.

J. Rectifier/Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

K. Batteries:

1. Description: Standard VRLA batteries.

a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

L. Integral Output Disconnecting Means and OCPD:

1. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

a. Normally Closed: Eight (8).

2.3 ENCLOSURES

A. Central Battery Equipment Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.
3. Audible alarm with silencer switch.

2.4 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate central battery equipment fabricator's quality-control and testing methods.

B. Testing: Test and inspect central battery equipment according to UL 924.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store central battery equipment according to NECA 411.

B. Examine areas, surfaces, and substrates to receive central battery equipment, with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.

C. Examine equipment before installation. Reject equipment that is wet, moisture damaged, or mold damaged.

D. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Coordinate layout and installation of central battery equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Floor-Mounted Central Battery Equipment: Install central battery equipment on 4-inch nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

E. Wiring Method: Install cables in raceways except within consoles and cabinets. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

F. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 CONNECTIONS

A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

C. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify central battery equipment, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label central battery equipment with engraved nameplates.
3. Label each separate cabinet, for multi-cabinet units.

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. Central battery equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test 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, and other adjustable parts.

C. Set the automatic system test parameters.

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 central battery equipment 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, and maintain central battery equipment, and to use and reprogram microprocessor-based control, monitoring, and display functions.

END OF SECTION 26 33 23

SECTION 26 51 19
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 LED luminaires

1.3 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, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied IES LM-79 or 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. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.4 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.

1.5 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.

2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.6 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. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 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: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Ambient Temperature: 5 to 104 deg F.

1. Relative Humidity: Zero to 95 percent.

B. Altitude: Sea level to 1000 feet.

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. 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.

C. Recessed luminaires shall comply with NEMA LE 4.

2.3 LED LUMINAIRES

A. LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria. The technical requirements that the luminaire shall meet for each Application Category are:

1. Minimum Light Output.
2. Zonal Lumen Requirements.
3. Minimum Luminaire Efficacy
4. Minimum CRI.
5. L70 Lumen Maintenance.

B. Additional requirements:

1. Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on the plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
2. Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
3. Luminaire shall be mercury-free, lead-free, and RoHS compliant.
4. Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
5. Light output of the LED system shall be measured using the absolute photometry method following IES LM-79 and IES LM-80 requirements and guidelines.
6. Luminaire shall maintain 70% lumen output (L70) for a minimum of 100,000 hours.
7. Lumen output shall not depreciate more than 20% after 10,000 hours of use.
8. Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
9. Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a minimum of 70 for exterior luminaires.
10. LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of the LED for the ambient temperature of the location the luminaire is to be installed. Rated case temperature shall be suitable for operation in the ambient temperatures typically found for the intended installation. Exterior luminaires to operate in ambient temperatures of -20°F to 122°F (-29°C to 50°C).
11. Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
12. Luminaire shall have a maximum Total Harmonic Distortion (THD) of <20% at full input power and across specified voltage range.
13. All connections to luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
14. All luminaires shall be provided with knockouts for conduit connections.
15. All luminaires shall have a minimum luminaire efficacy of 80 watts/square foot.

C. LED Luminaires used for Emergency Egress Lighting:

1. The failure of one LED shall not affect the operation of the remaining LEDs.

2.4 LED DRIVERS

A. General

1. Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the luminaire schedule on the drawings.
2. Driver shall have a rated life of 100,000 hours, minimum.
3. Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
4. Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full input power and across specified voltage range.
5. Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
6. Driver shall have a maximum Total Harmonic Distortion (THD) of <20% at full input power and across specified voltage range.
7. Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
8. Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per Class 2 UL listing.
9. Provide all of the following data on submittals:

    a. Input watts
    b. Power Factor (pf)
    c. Crest Factor (cf) at full input power
    d. Total Harmonic Distortion (THD).

B. Dimming Drivers:

1. LED driver shall be compatible with dimming controls where dimming is indicated on the plans. Dimmable drivers shall use Dimming Constant Current (DCC), Constant Voltage, or Pulse Width Modulation (PWM) operation.
2. Continuous Dimming Drivers: LED luminaires shall dim to (10%, 1%, or 0.1%) as specified in the Luminaire Schedule on the plans without visible flicker or “popcorn effect”. “Popcorn effect” is defined as the luminaire being on a pre-set dimmed level (less than 100%) and going to 100% prior to returning to the pre-set level when power is returned to the luminaire. Continuous Dimming Drivers shall use 0-10V control.

2.5 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. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:

1. Manufacturer's standard grade.
2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.6 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.

2.7 LUMINAIRE SUPPORT

A. Comply with requirements in Section 26 05 29 "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 A641/A641M, 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 luminaire installation.

C. 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 a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:

    a. Two 5/32-inch- diameter aircraft cable supports adjustable to 10 feet in length.
    b. Pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to 10 feet in length.
    c. Hook mount.

2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. 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.

4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 26 05 19 "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 26 05 53 "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.

3.6 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 26 09 43.23 "Relay-Based Lighting Controls."

END OF SECTION 26 51 19

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SECTION 26 52 13
EMERGENCY AND EXIT 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. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

    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. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

2.2 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Lighting Unit:

1. Emergency Lighting Unit: as indicated on Luminaire Schedule.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

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:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. 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.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power unit’s minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power unit’s minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units or signs, that are defective.

    a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 26 52 13

SECTION 27 10 00
STRUCTURED CABLING SYSTEM

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. T-series drawings.

1.2 SUMMARY

A. This Section covers items that are common to all components of a Structured Cabling System (Equipment Room Fittings, Communications Horizontal Cabling, Communications Backbone Cabling, etc.).

B. Where cabling specified in this section is to be used by equipment specified in other sections, the contractor installing the structured cabling shall coordinate with the other contractor(s) for the connection of that equipment.

1.3 ABBREVIATIONS & ACRONYMS

A. The following Abbreviations & Acronyms apply to this document. Some or all may apply to the project.

8P8C	Eight-Position, Eight-Conductor (Modular Jack type)
ACR-N*	Attenuation-to-Crosstalk Ratio (Near End)
ACR-F*	Attenuation-to-Crosstalk Ratio (Far End; prev. Equal Level Far End Crosstalk (ELFEXT))
APC	Angled Physical Contact (fiber optic connector end-face)
AXT	Alien Crosstalk
HC	Horizontal Cross-connect
IC	Intermediate Cross-connect
IDC	Insulation displacement connector
MC	Main Cross-connect
N	Newton (a unit of force)
NEXT*	Near End Cross Talk
PC	Physical Contact (fiber optic connector end-face)
RJ45	(RJ45S) Registered Jack (8P8C), keyed
RU	(Equipment) Rack Unit; 1.75-inches vertical spacing
RL	Return Loss
SFF	Small Form Factor (Fiber Optic Connector)
UPC	Ultra-Physical Contact (fiber optic connector end-face)
VCSEL	Vertical-Cavity Surface Emitting LASER
WAP (AP)	Wireless Access Point (Access Point)

* Power-sum versions of these tests indicated by prefix “PS-“.

1.4 DEFINITIONS

A. The following definitions apply to this document and its companion sections for clarification and direction. Some or all may apply to the project.

Channel	The end-to-end transmission path connecting interfaces of any two pieces of application-specific equipment. Equipment cords and work area cords are included in the channel.
Cross-Connect (X-C), Cross-Connection	A facility enabling the termination of cable elements and their interconnection or cross-connection. A connection scheme between cabling runs, subsystems, and equipment using patch cords or jumpers that attach to connecting hardware on each end.
Horizontal Cross-Connect (H-C)	[A group of connectors (e.g., patch panels, punch-down blocks) that allow (HC) horizontal, backbone, and equipment cabling to be cross-connected with patch cords or jumpers.
Main Cross-Connect (MX-C)	The cross-connect normally located in the (main) equipment room for cross- connection and interconnection of entrance cables, first-level backbone cables, and equipment cables.
Modular Patch Panel	A connecting hardware system that facilitates cable termination and cabling administration using patch cords or equipment cords.
Permanent Link	The permanently installed portion of horizontal cabling (excludes cordage).
Rack Unit	A unit of measure of vertical space in an equipment rack, cabinet or enclosure. One rack unit is equal to 1.75 inches (in).
Service Loop	A surplus of cable, typically located at or near the point of termination, to facilitate potential future changes.
Telecommunications Outlet	An assembly of components consisting of one or more connectors and a faceplate or housing.
Unshielded Twisted Pair (UTP) Cable	Twisted-pair cable without a metallic shield around pairs nor overall shield.

1.5 CONTRACTOR QUALIFICATIONS

A. Contractor shall have necessary certifications to provide for Guarantees as specified herein.

B. Contractor shall be an active participant in Installers Program operated by manufacturer of cabling or connectivity products used.

C. Contractor shall be participant in this program at time of Bidding and remain so throughout project.

D. Contractor shall have on the project team at a minimum one (1) Certified Installer trained by the manufacturer(s) of the cabling, hardware and accessories installed under this project.

E. At least one member of each test team shall be factory trained/certified in use of the test equipment. The project foreman shall have been factory trained in the use of the test equipment.

1.6 QUALITY ASSURANCE

A. The manufacturer(s) of cabling and connectivity components shall be a company specializing in and having a minimum of five years documented experience in producing products similar to those specified in this and related sections.

1.7 SUBMITTALS

A. Product Data: For each type of product indicated in the following sections.

B. Project Documentation: See Part 3 for requirements.

1.8 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications staff.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.9 WARRANTY

A. Special Warranty for Communications Structured Cabling: Manufacturer's standard form in which manufacturer of Cabling and Termination Hardware agrees to repair or replace components that fail in materials, workmanship or performance within specified warranty period.

PART 2 - PRODUCTS

2.1 GENERAL

A. Comply with NECA 1.

2.2 EQUIPMENT ROOM FITTINGS

A. Racks, Cabinets and Enclosures:

1. Equipment Racks: Hubbell (Nextframe series) HPW84RR19

a. General: Floor-mounted, modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.

b. Dimensions:

1) Mounting width compatible with EIA 310 standard, 19-inch panel mounting.
2) Height: 84-inches; 45 RU usable.
3) Width: 19-inches (nominal).
4) Depth: 24-inches (nominal).
5) Capacity: up to 2000 lbs., evenly distributed.

c. Construction:

1) Aluminum frame, base and mounting rails.
2) Open top, bottom and sides.
3) Mounting Rails (vertical):

a) Fixed front and rear.

b) Drilled and tapped to accommodate 12-24 screws.
c) Supply of screws (minimum of 48 each per cabinet).
d) EIA-standard hole pattern: 5/8-5/8-1/2 inch.

4) Finish: Manufacturer's standard, baked-polyester powder coat.

a) Color: Black.

5) Accessories:

a) Supply of spare screws (minimum of 48).

2. Grounding Components:

a. General: Products must comply with UL 467.
b. Horizontal Grounding Bar:

1) 3/16" x 3/4" x 19” copper ground bar.
2) Attachment screws (to match equipment rack, cabinet and/or enclosure).
3) 6-32 threaded holes with matching green screws.
4) Ground lug or provision for a bonding jumper.

B. Cable Runway:

1. Construction:

a. Material: 0.065 inch thick steel.
b. Tubular stringers support rungs.

1) Stringers shall be 1.5 inches high.
2) Rungs shall be welded to stringers and shall be spaced 9 inches on center.

c. Finish: Manufacturer's standard epoxy paint or baked-polyester powder coat.

1) Color: Black.

2. Width: As shown on drawings.
3. Supports:

a. Wall (side and end).
b. Rack.
c. All-Thread Rod with protective plastic covers.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with NECA 1.

3.2 EQUIPMENT ROOM FITTINGS

A. Racks, Cabinets and Enclosures:

1. Equipment Racks:

a. Provide equipment racks as shown on project drawings.
b. Assemble racks per manufacturer's recommendations. Remove paint at the point(s) of contact of assembly hardware or use internal-external tooth lock washers to pierce paint to maintain ground continuity.
c. Bolt racks to floor.
d. Secure racks to cable runway as described below.
e. Provide Horizontal and Vertical Cable Management in equipment racks as follows:

1) Provide horizontal cable management above and below each rack mounted patch panel.
2) Provide vertical cable management between adjacent equipment racks and at rack row ends.

f. Provide each rack with:

1) Ground bar and #6 AWG Ground lug.
2) Minimum of fifty (50) 12/24 mounting screws.
3) Minimum of twelve (12) releasable (e.g. "hook & loop") cable support ties.

g. Bond each rack mounted ground bar to telecommunications main grounding busbar (TMGB).

1) Use #6 or larger AWG copper conductor (green jacket).

B. Cable Runway:

1. Install cable runway in locations and at elevations shown on the drawings.
2. Coordinate layout and installation of communications equipment with other trades and with Owner's telecommunications staff.
3. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
4. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

END OF SECTION 27 10 00

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SECTION 28 46 21.11
ADDRESSABLE FIRE-ALARM 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. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Remote annunciator.
7. Addressable interface device.
8. NAC Extender Panels (NACP)

B. Related Requirements:

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations.

Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.

4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

    a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

g. Manufacturer's required maintenance related to system warranty requirements.
h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.

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. Smoke Detectors: Quantity equal to two percent (2%) of amount of each type installed, but no fewer than two unit of each type.
2. Detector Bases: Quantity equal to two percent (2%) of amount of each type installed, but no fewer than two unit of each type.
3. Keys and Tools: One extra set for access to locked or tamper proofed components.
4. Audible and Visual Notification Appliances: One of each type installed.
5. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.8 REGULATORY REQUIREMENTS

A. The complete installation shall conform to the applicable sections of the latest edition of the following Codes and Standards:

B. National Fire Protection Association (NFPA):

1. NFPA-70: National Electrical Code (NEC) generally, and Article 760 in particular
2. NFPA-72: National Fire Alarm Code
3. NFPA 101: Life Safety Code
4. IBC: International Building Code
5. IFC: International Fire Code
6. MC: International Mechanical Code

C. State of Wisconsin – Department of Safety and Professional Services (DSPS)

1. SPS 361.30: Plan Review Approval

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: One (1) year from date of Substantial Completion.
3. Warranty requirements shall include furnishing and installing all software upgrades issued by manufacturer during the one (1) year warranty period.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Replacement of existing fire alarm system in facility.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. 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 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
5. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.

3. Alert and Action signals of air-sampling detector system.
4. User disabling of zones or individual devices.
5. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.

2.3 FIRE-ALARM CONTROL UNIT

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

1. Fire-Lite Alarms, Inc.; a Honeywell International company.
2. Gamewell - FCI by Honeywell.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.
5. Edwards Signaling
6. Hochiki America Corporation

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

    a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
    b. Include a real-time clock for time annotation of events on the event recorder and printer.
    c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
    d. The FACP shall be listed for connection to a central-station signaling system service.

e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class B.
2. Pathway Survivability: Level 0.
3. Install no more than 50 addressable devices on each signaling-line circuit.
4. Serial Interfaces:

a. One dedicated RS 485 port for central-station operation using point ID DACT.
b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).

E. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.

3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

H. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.
b. Device type.
c. Present average value.

d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.
b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock mounting plate interchangeable with smoke detectors
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
2. Notification Appliance Circuits shall provide the features listed below. These requirements may require separate circuits for visual and audible devices.

a. Temporal audible notification for all audio appliances.
b. Synchronization of all visual devices where two or more devices are visible from the same location.
c. Ability to silence audible alarm while maintaining visual device operation.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red.

2.8 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Surface cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.9 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.10 NAC EXTENDER PANELS (NEP)

A. As shown on the plans or as a Contractor’s option if not shown, furnish and install NAC Extender Panels as necessary to provide remote power supply for notification appliance

circuits (NAC). Contractor shall indicate quantity and locations of each NEP on the shop drawing submittals. Acceptable locations for the NEP's are shown on the drawing or as directed by Engineer.

B. Each NEP shall be self-contained remote power supply with batteries, and battery charger mounted in a surface lockable cabinet. Battery capacity shall be sufficient for operation for 24-hours in a non-alarm state followed by alarm for 10 minutes, plus 25% spare capacity for future devices. Each NEP provides a minimum of up to 4 outputs, 2A continuous, or 6A full load total capacity.

C. Power for each NEP shall be from a local 120 VAC circuit. Provide two #12 conductors and one #12 ground in ½" conduit to each NEP from a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Coordinate panel and circuit number with Engineer prior to installation.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Existing DMP XR100/XR500 Digital alarm communicator transmitter shall be utilized and extended to the new fire alarm panel.

B. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

C. Secondary Power: Integral rechargeable battery and automatic charger.

D. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Expand, modify, and supplement existing control monitoring equipment as necessary to extend existing control functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
4. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 WIRING

A. Fire alarm wiring/cabling shall be furnished and installed by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes. Cabling shall be UL listed and labeled as complying with NFPA 70, Article 760 for power-limited fire alarm signal service.

1. Fire alarm wiring/cabling shall be provided by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes.
2. Wiring shall be installed in conduit in exposed construction.
3. Wiring shall be installed in conduit from device to above accessible ceilings. Exposed plenum-rated cable (FPLP) shall be used above accessible ceilings supported every 4 feet or run in cable trays (if applicable) maintaining a minimum of 5-inches clearance from all lighting ballasts.
4. Fire alarm cabling shall not be installed in the same bridle rings or cable trays designated for the cabling of other systems. All junction boxes shall be painted red with SLC and NAC circuits identified on cover.
5. Fire Alarm Power Branch Circuits: Building wiring as specified in Section 26 05 19.
6. Notification Appliance Circuits shall not span floors.
7. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be in fire alarm conduits. Wiring splices shall be avoided to the extent possible, and if needed, they shall be made only in junction boxes, and enclosed by plastic wire nut type connectors. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end, in all junction boxes, and at each device with "E-Z Markers" or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded, and no unterminated conductors are permitted in cabinets or control panels. All controls, function switches, etc. shall be clearly labeled on all equipment panels.

B. Fire Alarm Cabling Color Code: Provide circuit conductors with insulation color coding as follows or using colored tape at each conductor termination and in each junction box.

1. Power branch circuit conductors: In accordance with Section 26 05 19.
2. Signaling line circuit: Overall red jacket with black and red conductors.
3. DC power supply circuit: Overall red jacket with violet and brown conductors.

C. Devices surface mounted in areas shall be mounted on surface backboxes, furnished by fire alarm equipment supplier. Backboxes shall be painted to match device, and shall not have visible knockouts.

D. All conduit shall be painted red.

3.4 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 DEMONSTRATION

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

END OF SECTION 28 46 21.11

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SECTION 31 11 00
EROSION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Inlet Protection
2. Sediment Log
3. Temporary Seeding
4. Tracking Pad

B. Provide temporary erosion control measures to prevent soil erosion and discharge of soil bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation-control Drawings and requirements of authorities having jurisdiction. The Contractor shall provide erosion and sediment control in accordance with the Erosion Control Plan for the project. If a plan is not available, the Contractor shall provide erosion control as necessary.

1.2 PROJECT CONDITIONS

A. All erosion control devices specified in the plans must be installed before grading and stripping of topsoil.

PART 2 - PRODUCTS

2.1 MATERIALS – GENERAL

A. Provide materials as required by governing agencies and on the approved site or erosion control plans.

2.2 INLET PROTECTION FILTER

A. Install inlet protection filters as listed in the Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List for Multi-Modal Applications.

2.3 SEDIMENT LOG

A. Sediment log shall be a minimum of 12” in diameter and listed in the WisDOT Erosion Control Product Acceptability List for Multi-Modal Applications.

2.4 TEMPORARY SEEDING

A. Temporary Seed Mixture Components.

Lbs/1000 SF	Species	Min. % Purity	Min. % Germ.
2	Oats	98	90
2.5	Rye	97	85

2.5 TRACKING PAD

A. Per the plans.

PART 3 - EXECUTION

3.1 PROCEDURES AND MAINTENANCE

A. Install silt fences and filter barriers at the beginning of the project.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established. Measures shall be inspected on a weekly basis and after a precipitation event of 0.5 inches or greater in a 24 hour period. Document inspections and maintenance performed.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal. Removal of measures shall be after the site is 80 % stabilized (or approved by local, county, or state erosion control agency).

E. The Contractor shall install erosion control measures including but not limited to:

1. Silt Fence
2. Tracking Pad
3. Sediment Log
4. Temporary Seeding

F. Minimize disturbed area. Stripping of vegetation, re-grading or other development shall be done in such a manner as to minimize erosion.

G. Development plans shall preserve salient natural features, minimize land cuts and fills, and conform to the general topography so as to create the least erosion potential and to adequately contain the volume and velocity of surface water runoff.

H. To the largest degree feasible, natural vegetation shall be retained, protected and supplemented. Disturbed areas and the duration of exposure thereof shall be kept to a practicable minimum and stabilized as quickly as practicable. Temporary vegetation and/or mulching shall be used to protect exposed critical areas during development.

I. Permanent (final) vegetation and structural erosion control and drainage measures shall be installed as soon as practicable during development.

J. Provisions shall be made to effectively accommodate the increased runoff caused by changed soil and surface conditions, both during and after development. Where necessary, the rate of surface water runoff shall be structurally retarded.

K. Sediment in the runoff water shall be trapped until the disturbed area is stabilized by the use of debris or sediment basins, silt traps or similar measures.

L. Locate stockpiles of soils away from waterways and wetlands.

1. Protect soil stockpiles with erosion mat, seed and mulch or cover with tarpaulins or burlap.
2. All stockpiles shall have the base of the pile protected with sediment log around the base of the pile.

M. All erosion and sedimentation devices shall be inspected and repaired in the following frequencies:

1. Weekly
2. After each rainfall
3. Daily during prolonged rainfall

N. Sediment shall be removed after devices become one-third full.

O. Repair all washouts.

P. Maintain temporary erosion and sedimentation control structures until permanent soil erosion controls are completed and/or vegetation is established.

1. Repair damaged structures.
2. Replace lost structures.
3. Remove sediment on a regular basis.
4. Refill eroded areas as required for grade stabilization.

3.2 EARTH STRUCTURES

A. Maintain temporary erosion and sedimentation control structures until permanent soil erosion controls are completed and/or vegetation is established.

1. Repair damaged structures.
2. Replace lost structures.
3. Remove sediment on a regular basis.
4. Refill eroded areas as required for grade stabilization.

3.3 ADJUST AND CLEAN

A. Clean premises of all litter and debris created by work of this Section.

END OF SECTION 31 11 00

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SECTION 31 20 00
EARTH MOVING

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. Excavating and filling for rough grading the Site.
2. Preparing subgrades for pavements.
3. Subbase course and base course for asphalt paving.
4. Excavating and backfilling for utility trenches.
5. Excavating and backfilling trenches for utilities and pits for buried utility structures.
6. Erosion Control
7. Excavating and Backfilling for Buildings and Structures.
8. Drainage course for concrete slabs-on-grade.
9. Subsurface drainage backfill for walls.

B. Related Sections:

1. Refer to Section 31 23 19 “Dewatering”
2. Refer to Section 31 11 00 “Erosion Control”
3. Refer to Section 32 92 00 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subgrade and hot-mix asphalt paving.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Owner's Representative. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by OWNER'S REPRESENTATIVE. Unauthorized excavation, as well as remedial work directed by OWNER'S REPRESENTATIVE, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

J. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

K. Sand: Clean, natural sand.

1.4 SUBMITTALS

A. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 698 for non-supporting sections and ASTM D 1557 for supporting sections for each on-site and borrow soil material proposed for fill and backfill.

B. Field Quality Test Reports: From a qualified independent geotechnical engineering testing agency indicating subgrade, fill and backfill bearing capacities and degree of compaction.

C. Contaminated soils and dewatering water disposal daily log, testing reports and quantity from receiving landfill. Dewatering water disposal shall be incidental.

1.5 PRE-INSTALLATION MEETINGS

A. Pre-installation Conference: Conduct pre-excavation conference at Project site.

1. Review methods and procedures related to earthmoving, including, but not limited to, the following:

a. Personnel and equipment needed to make progress and avoid delays.
b. Coordination of Work with utility locator service.
c. Extent of trenching by hand or with air spade.
d. Field quality control.
e. Coordination of work to maintain access to building during construction.

1.6 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations. Assure access to either north or south side of building at all times during construction.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Government and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Government or authorities having jurisdiction.

B. Utility Locator Service: Notify Digger's Hotline for area where Project is located before beginning earth-moving operations.

C. Do not commence earth-moving operations until inlet protection is installed.

D. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Owner not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

E. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM C 294; with

1. 3/4-inch Mix: At least 95 percent passing a 3/4-inch sieve, 40-75 percent passing a 3/8-inch sieve, 25-60 percent passing a No. 4 sieve and not more than 8 percent passing a No. 200 sieve.

E. Breaker Run: Crushed stone; predominantly 6-inches or less in one direction and not more than 8 percent passing a No. 200 sieve. The size of the material shall be predominantly 3-inches to 6-inches.

F. Bedding Course or Clean Stone: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 3/4-inch sieve and not more than 5 percent passing a No. 200 sieve.

G. Drainage Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 3/4-inch sieve and not more than 5 percent passing a No. 200 sieve.

H. Engineered Fill: 3/4-inch Mix: At least 95 percent passing a 3/4-inch sieve, 40-75 percent passing a 3/8-inch sieve, 25-60 percent passing a No. 4 sieve and not more than 8 percent passing a No. 200 sieve.

I. Sand: Clean granular material meeting the requirement in Section 501.2.5.3.4 of the Wisconsin DOT Standard Specifications for Highway Construction.

J. Geotextile Filter Fabric: Fabric shall meet the requirements of Section 645.2.4, Type DF, Schedule B or C of the Wisconsin DOT Standard Specifications for Highway Construction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. See Section 31 23 19 “Dewatering.”

B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.4 EXCAVATION IN CONTAMINATED SOILS AREAS

A. Contaminated soils may exist within the project extents and excavation areas. Previous soil exploration did not identify contaminated soils, but underground petroleum tanks are present on the site. If contaminated soils or groundwater are encountered during site excavations, contact the Owner immediately.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots.

3.6 EXCAVATION FOR UTILITIES AND TANKS

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course, or to depth shown on the plans whichever is greater.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.7 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.8 SUBGRADE INSPECTION

A. Notify OWNER'S REPRESENTATIVE when excavations have reached required subgrade.

B. If OWNER'S REPRESENTATIVE determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction. Limit vehicle speed to 3 mph (5 km/h).
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by OWNER'S REPRESENTATIVE, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by OWNER'S REPRESENTATIVE, without additional compensation.

3.9 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Removing concrete formwork.
3. Removing trash and debris.
4. Removing temporary shoring, bracing, and sheeting.
5. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.11 SOIL FILL

A. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

B. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.12 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.13 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

1. Under structures, buildings, steps and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
2. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
3. For utility trenches, outside of supporting pavements, compact each layer of initial and final backfill soil material at 92 percent per ASTM D 698.

3.14 UTILITY TRENCH BACKFILL

A. Place backfill that is free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated on plans. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. For conduit less than 30 inches below surface of pavements, provide 4-inch thick, concrete-base slab support. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway base course.

D. Backfill utility trenches under future pavements with select backfill. All other trenches may be backfilled with satisfactory soil. Backfill to be compacted in 8 inch maximum lifts to a density of 95 percent compaction per ASTM D 1557.

E. Place and compact initial backfill, free of particles larger than 1 inch in any dimension over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.15 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:

1. Turf or Unpaved Areas: Plus or minus 1/2 inch.
2. Pavements: Plus or minus 1/8 inch.

3.16 SUBSURFACE DRAINAGE

A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch (150-mm) course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches (300 mm) of filter material, placed in compacted layers 6 inches (150 mm) thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.

B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches (300 mm) of final subgrade, in compacted layers 6 inches (150 mm) thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.
2. Place and compact impervious fill over drainage backfill in 6-inch- (150-mm-) thick compacted layers to final subgrade.

3.17 BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place base course under pavements and walks as follows:

1. Place base course material over subbase course under hot-mix asphalt pavement.
2. Shape base course to required crown elevations and cross-slope grades.
3. Place base course 6 inches or less in compacted thickness in a single layer.

4. Place base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
5. Compact base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

C. Pavement Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.18 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place drainage course 6 inches (150 mm) or less in compacted thickness in a single layer.
3. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.19 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
2. Determine that fill material classification and maximum lift thickness comply with requirements.
3. Determine, during placement and compaction that in-place density of compacted fill complies with requirements.
4. Witness and approve proof roll of subgrade.

B. Testing Agency: Contractor shall engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 400 sq. ft. or less of paved area or building slab but in no case fewer than three tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by OWNER'S REPRESENTATIVE; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Government's property.

B. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 20 00

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SECTION 31 23 19
DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes construction dewatering.

1.2 REFERENCES

A. Wisconsin Administrative Code (WAC):

B. Chapter NR 141 – Monitoring Well Construction

C. Chapter NR 812 – Well Construction and Pump Installation

D. Wisconsin Department of Natural Resources Technical Standards for Construction Site Erosion & Sediment Control (Technical Standards): http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm#Construction

1.3 RELATED SECTIONS

A. Refer to Section 31 20 00 “Earth Moving.”

B. Refer to Section 31 23 19 “Dewatering.”

1.4 ACTION SUBMITTALS

A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. The plan shall include the location of dewatering practices, staging of dewatering, where water will be pumped from, rate of pumping, details of sediment removal practice and polymer approval from WDNR (if polymer is used).
3. For deep wells or well point systems, provide copies of the site assessment, system design computations for removal of groundwater, and design information for sediment removal practices. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
4. For sump dewatering in trenches or excavations, provide copies of sediment removal practice selection and discharge design calculations or information.
5. Provide copies of all permits required for dewatering.
6. Provide copies of daily monitoring and testing logs for dewatering practices as described in the DNR Dewatering Technical Standard.
7. Provide copies of all borehole abandonment forms.

B. Permits.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in dewatering work.

1.6 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
2. The geotechnical report is included elsewhere in Project Manual.

1.7 PERMITS

A. Pay for and obtain all permits/approval required by state and federal regulations.

B. Necessary permits/approval includes, but is not limited to

1. High capacity well approval under NR 812.09. Sump dewatering is not included in high capacity dewatering unless pumping rate is > 70 gallons per minute and is generally covered under the site erosion control permit. http://dnr.wi.gov/topic/Wells/HighCapacity.html
2. If groundwater dewatering, groundwater dewatering permit may be required. Coordinate with Materials Management Plan. Wastewater pit/trench dewatering permit (WI-0049344) contact Dave Brick (608-275-3321), wastewater specialist. This permit, fact sheet and request for coverage form at: http://dnr.wi.gov/topic/wastewater/GeneralPermits.html

C. When installing by jetting methods, provide own water source. Do not use hydrants as water source without permission from Construction representative and/or local utility, as applicable. Obtain and pay for any required hydrant use and permits.

D. Comply with erosion control permit. Inspect dewatering system daily for erosion issues and add erosion control as necessary.

1.8 SAFETY

A. Prevent public access to dewatering system components.

B. Abandon boreholes in accordance with applicable state and federal codes immediately following use.

C. When pumping groundwater from contaminated soils area, follow Materials Management Plan.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Design dewatering system, including comprehensive engineering analysis by a qualified professional.
2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
3. Prevent surface water from entering excavations by grading, dikes, or other means.
4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
5. Remove dewatering system when no longer required for construction.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water and debris disposal regulations of authorities having jurisdiction.

C. All deepwell and wellpoint dewatering equipment and well construction/abandonment materials shall meet the requirements of NR 141 and NR 812.

D. Sump or trench dewatering shall use portable sediment removal devices and meet the requirements of DNR Technical Standard 1061. Portable sediment removal devices include but are not limited to: filter tanks, Type II Geotextile Bags with polymer addition and portable sand filters.

E. Polymers used in dewatering to settle particles shall meet the DNR Technical Standard 1051 criteria and shall be approved by WDNR.

PART 3 - EXECUTION

3.1 PREPARATION

A. Comply with local, state and federal regulations.

B. If contaminated soils or groundwater are encountered during site excavations contact the Owner immediately. Special dewatering procedures may be required.

C. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

D. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

E. Provide temporary grading to facilitate dewatering and control of surface water.

F. Protect and maintain temporary erosion and sedimentation controls, which are specified in 31 11 00 “Erosion Control” during dewatering operations.

G. When deep wells or well point systems are utilized, prepare a system design and obtain permits in accordance with NR 812.09 for high capacity wells as defined by NR 812.07(53). Design system to dewater site as necessary to complete construction but minimize impact on local water table. Monitor water levels in wells adjacent to construction site. Adjust dewatering system configuration and operation as necessary if neighboring wells are adversely impacted. Do not adversely impact neighboring private wells.

H. Coordinate dewatering with other contractors.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
3. Maintain piezometric water level a minimum of 24” below bottom of excavation.

C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

C. Prepare reports of observations daily. Daily records shall be kept of:

1. Discharge duration and rate
2. Observed water table at time of dewatering
3. Type and amount of polymer used
4. Maintenance activities

3.5 PROTECTION

A. Protect and maintain dewatering system during dewatering operations.

B. Promptly repair damages to adjacent facilities caused by dewatering.

C. Remove dewatering system immediately after dewatering is complete in accordance with all state, local and federal regulations.

END OF SECTION 31 23 19

SECTION 31 66 15
HELICAL PILES

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 designing, furnishing, installing, and testing Helical Piles and Bracket Assemblies in accordance with the Drawings and this specification. Helical Piles shall be installed at the locations and to the elevation, minimum depth, and allowable superimposed load capacities shown on the Drawings or as established herein. This work also includes load testing and pre-loading Helical Piles.

1.3 REFERENCED CODES AND STANDARDS

A. This specification is based on nationally recognized codes and standards including the references listed below. In case of a conflict between the reference and this specification, this specification shall govern.

B. American Society for Testing and Materials (ASTM)

1. ASTM A36/A36M Structural Steel
2. ASTM A123-02 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. ASTM A153-05 Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
4. ASTM A450/A450M-07 Standard Specification for General Requirements for Carbon and Low Alloy Steel Tubes
5. ASTM D1143/D1143M-07 Standard Test Method for Piles Under Static Axial Compressive Load
6. ASTM D3689 Standard Test Method for Individual Piles Under Static Axial Tensile Load
7. ASTM D3966-07 Standard Test Method for Piles Under Lateral Loads

C. American Society of Mechanical Engineers (ASME)

1. ANSI/ASME Standard B18.2.1-1996, Square and Hex Bolts and Screws, Inch Series

D. Occupational Safety and Health Administration (OSHA)

1. Excavation Safety Guidelines

E. ICC-Evaluation Services, Inc.

1. AC358 Acceptance Criteria for Helical Foundation Systems and Devices

F. American Welding Society

1. ANSI/AWS B2.1-00 Standard for Welding Procedure and Performance Qualification

1.4 DEFINITIONS

A. Allowable Capacity: Ultimate capacity divided by a factor of safety.

B. Augering: Rotation of the shaft with little or no advancement. It can occur when the helical bearing plates pass from a relatively soft material into a comparatively hard material. Augering can also result from insufficient crowd or downward pressure during installation. In some cases, augering may be (temporarily) necessary in order to grind through an obstruction.

C. Brackets: Cap plate, angle, thread bar, or other termination device that is bolted or welded to the end of a Helical Pile after completion of installation to facilitate attachment to structures or embedment in cast-in-place concrete.

D. Crowd: Axial compressive force or pressure applied to the helical pile as needed during installation to ensure the pile progresses into the ground a distance approximately equal to the helix pitch per revolution.

E. Extension Section: Helical Pile or sections that follow the Lead Section into the ground and extend the Helical Lead to the appropriate depth. Extension Sections consist of a central shaft and may have helical bearing plates affixed to the shaft.

F. Geotechnical Capacity (a.k.a. Ultimate Soil Capacity): The maximum load that can be resisted through bearing of helix plates in the soil which they are embedded.

G. Helical Pile: Manufactured steel foundation with one or more helical bearing plates that is rotated into the ground to support structures.

H. Helical Anchor: Same as a Helical Pile. Term generally used when axial tension is the primary service load. The term “Helical Pile” will be used throughout this specification for simplicity.

I. Lead Section: The first section of a Helical Pile to enter the ground. Lead Sections consist of a central shaft with a tapered end and one or more helical bearing plates affixed to the shaft.

J. Pile Design Professional: Registered Professional Engineer, licensed in the State of the project responsible for the design of Helical Piles and Brackets.

K. Safety Factor: The ratio of the ultimate resistance available to the nominal load used for the design of any helical pile component or interface (Allowable Stress Design).

1.5 DESIGN AND PERFORMANCE REQUIREMENTS

A. Helical piles shall be designed to support the allowable loads indicated on the project plans. The overall length, helix configuration and minimum torsional resistance of a

helical pile shall be such that the required Geotechnical Capacity is developed by the helix plate(s) in an appropriate bearing stratum.

1. The Geotechnical Capacity of the Helical Piles shall be determined using bearing only and shall not include any load-resisting contribution from skin friction on the shaft of the Helical Pile. The effects of down-drag on the shaft of the Helical Pile shall be considered in reducing the available load-resisting capacity of the pile.

B. All steel structure pile components shall be designed within the limits provided by the American Institute of Steel Construction (AISC). Either Allowable Stress Design (ASD) or Load & Resistance Factor Design (LRFD) are acceptable methods of analysis. Product testing in accordance with ICC-ES Acceptance Criteria 358 may also be considered as an acceptable means of establishing allowable system capacities.

C. All piles shall be installed to provide a minimum factor of safety against ultimate bearing resistance of 3. Design piles to limit settlement to a maximum of 0.5 inch.

D. The pile design shall take into account such pile spacing, soil stratification, down-drag, corrosion and strain compatibility issues as are present for the project.

E. Pile designer to design connection to anchor rods including provision for pile location tolerance.

1.6 QUALITY ASSURANCE

A. Due to the special requirements for manufacture and quality control of Helical Piles and Brackets, all Helical Piles and Brackets shall be obtained from a company specializing in the manufacturing and distribution of these products. The Manufacturer shall have the following qualifications:

1. Documentation showing manufacturer has at least 3 years of experience in the design and manufacture of Helical Piles and that the Manufacturer's Helical Piles have been used successfully in at least 3 engineered construction projects within the last 3 years.
2. Current ICC-ES product evaluation report or complete description of product testing and engineering calculations used to assess product capacity.
3. Manufacturer shall have established product testing and manufacturing quality assurance programs to assess and maintain product quality. A complete description of these programs shall be included with the Manufacturer qualifications submittal.

B. Due to the special requirements for installation of Helical Piles and Brackets, all Helical Piles and Brackets shall be installed by an organization specializing in the installation of those products. The Installer shall have the following qualifications:

1. Documentation the Installer has completed training in the proper methods of installation of Helical Piles and the mounting of Brackets.
2. Resume of Installer's foreman including experience in the oversight of Helical Pile installation on at least three projects in the last 3 years, including project name, number and type of Helical Piles installed, project location, and client contact information.

3. List of installation and testing equipment and detailed description of proposed method of installation and load testing Helical Piles.
4. Current ANSI/AWS welding certificate and documentation of welder experience within the last 3 years.

C. The Contractor shall engage a Pile Design Professional specialized in the engineering and design of Helical Piles to design all Helical Piles and Brackets. The Pile Design Professional shall have the following qualifications:

1. At least five (5) years of experience in this type of work as well as graduate education in structural and/or geotechnical engineering.
2. Documentation of Pile Design Professional having designed Helical Piles on one project, including project name, number and type of Helical Piles, project location, and client contact information.
3. Professional errors and omissions liability insurance certificate.
4. Documentation of current license to practice engineering in the project state.

D. Manufacturer shall provide a one (1) year warranty against manufacturing defects on Helical Pile and Bracket products.

1.7 ACTION SUBMITTALS

A. Shop Drawings: Submit for review and approval, Shop Drawings and specifications for the Helical Piles intended for use on the project. Installation shall not begin until shop drawings are approved. The Shop Drawings shall include the following:

1. Helical Pile product identification number(s) and designation(s)
2. Maximum allowable mechanical compression and tensile strength of the Helical Piles
3. Number of Helical Piles and respective design allowable capacities from the Drawings
4. Planned installation depth and the number of lead and extension sections
5. Preliminary helical configuration (number and diameter of helical bearing plates)
6. Manufacturer’s recommended capacity to installation torque ratio
7. Minimum final installation torque(s)
8. Product identification numbers and designations for all Bracket Assemblies and number and size of connection bolts or concrete reinforcing steel detail
9. Corrosion protection coating on Helical Piles and Bracket Assemblies
10. Product data: Include technical data for all commodity products used.
11. Site plan

    a. Dimensioned pile layout.
    b. Field located existing utilities and obstructions. Provide plan and elevation dimensions.

B. Delegated-Design Submittal: Contractor shall submit design calculations and analysis data signed and sealed by the Pile Design Professional for the Helical Piles and Brackets intended for use on the project. Fabrication of custom piles shall not begin and orders for standard piles shall not be placed until delegated design submittal is approved. The design calculations shall include the following:

1. Reduction in shaft dimension and strength by the sacrificial thickness anticipated based on corrosion loss over the design life for project soil conditions.
2. Considerations for downdrag, buckling, and expansive soils (as appropriate).
3. Minimum installation depth to reach bearing stratum and to achieve pullout capacity (if required).
4. Soil bearing and pullout capacity.
5. Lateral resistance of the shaft (if required).
6. Estimated pile head movement at design loads.

1.8 SHIPPING, STORAGE, AND HANDLING

A. All Helical Pile and Bracket Assemblies shall be free of structural defects and protected from damage. Store Helical Piles and Bracket Assemblies on wood pallets or supports to keep from contacting the ground. Damage to materials shall be cause for rejection.

PART 2 - PRODUCTS

2.1 HELICAL PILES AND BRACKETS

A. The Contractor's Pile Design Professional shall select the appropriate size and type of Helical Piles and Brackets to support the design loads shown on the Drawings. These specifications and the Drawings provide minimum requirements to aid the Contractor in making appropriate materials selections. The size and number of helical bearing plates must be such that the Helical Piles achieve the appropriate torque and capacity in the soils at the site within the minimum depth requirements. Failure to achieve proper torque and capacity shall result in Contractor replacing Helical Piles as appropriate to support the required loads. All material replacements shall be acceptable to Engineer.

B. The design strength of the helical bearing plates, shaft connections, Brackets, and the pile shaft itself shall be sufficient to support the design loads specified on the Drawings multiplied by appropriate service load factors. In addition, all Helical Piles shall be manufactured to the following criteria.

1. Central Shaft: The central shaft shall consist of a high strength structural steel tube meeting the requirements of ASTM A513.
2. Helical Bearing Plates: One or more helical bearing plates shall be affixed to the central shaft. Helical bearing plates shall be attached to central shafts via fillet welds continuous on top and bottom and around the leading edges.

    a. Helical bearing plates shall be cold pressed into a near perfect helical shape that when affixed to the central shaft are perpendicular with the central shaft, of uniform pitch, and such that the leading and trailing edges are within ¼ inch of parallel.
    b. Average helical pitch shall be within plus or minus ¼ inch of the thickness of the helical bearing plate plus 3 inches.
    c. All helical bearing plates shall have the same pitch.
    d. Helical bearing plates shall have circular edge geometry.
    e. Helical bearing plate spacing along the shaft shall be between 2.4 and 3.6 times the bearing plate diameter.

f. Helical bearing plates shall be arranged such that they theoretically track the same path as the leading bearing plate.

3. Corrosion Protection: Helical Piles and Brackets shall be hot-dip galvanized (per ASTM A123 or A153 as applicable) after fabrication. Apply zinc-rich field coating to any/all galvanized surfaces damaged by welding or other operations.
4. Shaft Connections: The Helical Pile shaft connections shall consist of an external sleeve connection or a welded connection. External sleeve connections shall be in-line, straight and rigid and shall have a maximum tolerable slack of 1/16-inch. Welded connections shall consist of a full penetration groove weld all-around the central shaft. Shaft connections shall have a flexural strength at least as great as the shaft itself.
5. Bolts: Bolt holes through the external sleeve and central shaft shall have a diameter that is 1/16th inch greater than the bolt diameter. Bolts and nuts used to join Helical Pile sections at the shaft connections shall be hot-dip galvanized to match the central shaft. All Helical Pile bolts shall be securely snug tightened.
6. External sleeve: External sleeve Helical Pile shaft connections shall consist of a high strength structural steel tube outer sleeve meeting the requirements of ASTM A513. The outer sleeve shall be welded to the central shaft via a continuous fillet weld all-around. The fillet weld shall have a throat thickness equal to the external sleeve tube thickness.

C. Helical Piles shall be fitted with a manufactured Bracket that facilitates connection to the structure. Brackets shall be rated for the design loads shown on the Drawings. Brackets shall be affixed to the end of Helical Piles via bolts, plug welds, or continuous penetration welds meeting the requirements for shaft connections given previously in these specifications.

D. Retrofit Helical Piles shall include brackets for connection to existing grade beams or foundation walls. Design of the brackets, connection of brackets to the existing, and connection to the helical pile is by the helical pile professional engineer.

E. Helical Piles shall be hot-dip galvanized according to ASTM A-123.

PART 3 - EXECUTION

3.1 PLACEMENT REQUIREMENTS

A. Helical Piles shall be installed in all locations indicated on the drawings.

3.2 EXAMINATION

A. Contractor shall make extensive effort to locate all utilities and structures above and underground in the area of the Work. Contractor shall hydroexcavate to determine the exact location of underground utilities and buried structures within a distance from a Helical Pile equal to three times the maximum helix diameter. The Contractor shall request marking of underground utilities by an underground utility location service as required by law, and shall avoid contact with all marked underground facilities. Contractor is responsible for protection of all utilities and underground facilities.

B. Contractor shall review the contract drawings and project Geotechnical Report to determine subsurface conditions for sizing and installation of Helical Piles. In addition, Contractor shall make a site visit to observe conditions prior to the start of Work.

C. Contractor shall notify Engineer of any condition that would affect proper installation of Helical Piles immediately after the condition is revealed. Contractor shall halt installation work until the matter can be resolved to the satisfaction of the Engineer. Costs associated with an unforeseen condition that could have been inferred by a reasonable Contractor from the contract drawings and the available geotechnical data shall not be the responsibility of the Owner.

D. The Contractor shall have the option of performing additional subsurface tests using methods subject to the review and acceptance of the Engineer in order to establish final helical bearing plate configurations based on local soil conditions. The data collected along with other information pertinent to the project site shall be used to determine the required helical bearing plate configuration.

E. If excavation is required for proper installation of Helical Piles, Contractor shall make safe excavations in accordance with OSHA standards. All excavations greater than 20 feet in depth or not in strict accordance with OSHA standard details shall be designed by a registered design professional specializing in the design of excavations and shoring. The costs of all excavations, shoring, and related design shall be born by the Contractor.

3.3 INSTALLATION EQUIPMENT

A. Torque Motor: Helical Piles should be installed with high torque, low RPM torque motors, which allow the helical plates to advance with minimal soil disturbance. The torque motor shall be hydraulic power driven with clockwise and counter-clockwise rotation capability. The torque motor shall be adjustable with respect to revolutions per minute during installation. Percussion drilling equipment shall not be permitted. The torque motor shall have torque capacity greater than the minimum final installation torque required for the project. The connection between the torque motor and the installation rig shall have no more than two pivot hinges oriented 90 degrees from each other. Additional hinges promote wobbling and affect lateral capacity.

B. Installation Equipment: The installation equipment shall be capable of applying adequate crowd and torque simultaneously to ensure normal advancement of the Helical Piles. The equipment shall be capable of maintaining proper alignment and position.

C. Drive Tool: The connection between the torque motor and Helical Pile shall be in-line, straight, and rigid, and shall consist of a hexagonal, square, or round kelly bar adapter and helical shaft socket. To ensure proper fit, the drive tool shall be manufactured by the Helical Pile manufacturer and used in accordance with the manufacturer's installation instructions.

D. Connection Pins: The central shaft of the Helical Pile shall be attached to the drive tool by ASME SAE Grade 8 smooth tapered pins matching the number and diameter of the specified shaft connection bolts. The connection pins should be maintained in good condition and safe to operate at all times. The pins should be regularly inspected for wear and deformation. Pins should be replaced with identical pins when worn or damaged.

E. Torque Indicator: A torque indicator shall be used to measure installation torque during installation. The torque indicator can be an integral part of the installation equipment or externally mounted in-line with the installation tooling. The torque indicator shall be capable of torque measurements with a sensitivity of 500 ft-lb or less. Torque indicators shall have been calibrated within 1-year prior to start of Work. Torque indicators that are an integral part of the installation equipment shall be calibrated on-site. Torque indicators that are mounted in-line with the installation tooling shall be calibrated either on-site or at an appropriately equipped test facility. Indicators that measure torque as a function of hydraulic pressure shall be re-calibrated following any maintenance performed on the torque motor. Torque indicators shall be re-calibrated if, in the opinion of the Engineer, reasonable doubt exists as to the accuracy of the torque measurements.

3.4 INSTALLATION PROCEDURES

A. Contractor shall furnish and install all helical piles per the project plans and approved pile design documentation. In the event of conflict between the project plans and the approved pile design documentation, the Contractor shall not begin construction on any affected items until receiving direction by the Engineer.

B. The number and size of helical blades shall be determined by the Contractor's Pile Design Professional in order to achieve the required torque and tensile/bearing capacity for the soil conditions at the site. The ratio of design load to the total area of the helical bearing plates shall not exceed the Allowable Bearing Capacity.

C. Connect the lead section to the Torque Motor using the Drive Tool and Connection Pins. Position and align the Lead Section at the location and to the inclination shown on the Drawings and crowd the pilot point into the soil. Advance the Lead Section and continue to add Extension Sections to achieve the Termination Criteria. All sections shall be advanced into the soil in a smooth, continuous manner at a rate of rotation between 5 and 25 revolutions per minute. Snug tight all coupling bolts.

1. The lead section shall be positioned at the location as shown on the pile design drawings. Inclined helical piles can be positioned perpendicular to the ground to assist in initial advancement into the soil before the required batter angle shall be established. After initial penetration, the required inclination angle shall be established.
2. Constant axial force (crowd) shall be applied while rotating Helical Piles into the ground. The crowd applied shall be sufficient to ensure that the Helical Pile advances uniformly into the ground a distance approximately equal to the blade pitch per revolution during normal advancement.
3. The rate of rotation and magnitude of down pressure shall be adjusted for different soil conditions and depths.

D. The manufacturer's torsional strength rating of the Helical Pile shall not be exceeded during installation.

E. Bolt-hole elongation due to torsion of the shaft of a Helical Pile at the drive tool shall be limited to 1/4-inch. Helical Piles with bolt-hole damage exceeding this criterion shall be uninstalled, removed, and discarded.

F. When the Termination Criteria of a Helical Pile is obtained, the Contractor shall adjust the elevation of the top end of the shaft to the elevation shown on the Drawings or as required. This adjustment may consist of cutting off the top of the shaft and drilling new holes to facilitate installation of Brackets to the orientation shown on the Drawings. Alternatively, installation may continue until the final elevation and orientation of the pre-drilled bolt holes are in alignment. Contractor shall not reverse the direction of torque and back-out the Helical Pile to obtain the final elevation.

G. The Contractor shall install Brackets as directed by the Helical Pile manufacturer.

H. All Helical Pile components, including the shaft and Bracket, shall be isolated from making a direct electrical contact with any concrete reinforcing bars or other non-galvanized metal objects since these contacts may alter corrosion rates.

I. The Helical Pile installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project.

3.5 TERMINATION CRITERIA

A. Helical Piles shall be advanced until all of the following criteria are satisfied.

1. Axial capacity is verified by achieving the final installation torque as provided by the Pile Design Professional.
2. Minimum depth is obtained. The minimum depth shall be as required to ensure all helical bearing plates are located below any OH/OL strata (see Section 1.5.F), or the depth at which the final installation torque is measured, whichever is greater. In addition, Helical Piles shall be advanced until the average torque over the last three (3) feet equals or exceeds the required final installation torque.

B. If the torsional strength rating of the Helical Pile and/or the maximum torque of the installation equipment has been reached or Augering occurs prior to achieving the minimum depth required, the Contractor shall have the following options:

1. Terminate the installation at the depth obtained subject to the review and acceptance of the Engineer and Owner.
2. Remove the Helical Pile and install a new one with fewer and/or smaller diameter helical bearing plates or with dual cutting edge helical bearing plates. The new helical configuration shall be subject to review and acceptance of the Engineer.
3. Remove the Helical Pile and pre-drill a 4-inch diameter pilot hole in the same location and reinstall the anchor/pile.
4. If the obstruction is shallow, remove the Helical Pile and remove the obstruction by surface excavation. Backfill and compact the resulting excavation and reinstall the anchor/pile.
5. Remove the Helical Pile and relocate 1-foot to either side of the installation location subject to the review and acceptance of Engineer.
6. Reverse the direction of torque, back-out the Helical Pile a distance of 1 to 2 feet and attempt to reinstall by decreasing crowd and Augering through the obstruction.
7. Remove the Helical Pile and sever the uppermost helical bearing plate from the Lead Section if more than one helical bearing plate is in use, or reshape the

helical bearing plates to create a special tapered edge by cutting with a band saw. Reinstall the anchor or pile with revised helical bearing plate configuration.

C. The Contractor shall install all Helical Piles to the depth required to achieve the specified installation torque by using additional Extension Sections.

3.6 ALLOWABLE TOLERANCES

A. Helical Piles shall be installed within 2-inches of the indicated plan location.

B. Helical pile shaft alignment shall be within 5 degrees of the inclination angle shown on the plans.

1. Unless otherwise noted, Helical Piles indicated on the plans are to be vertical.

C. Top elevation of helical piles shall be within ½ inch of the design vertical elevation.

3.7 FIELD QUALITY CONTROL

A. Engage a qualified, independent testing and inspection agency acceptable to the Engineer to observe and document a minimum of 10 percent of Helical Pile installations. The inspection agency shall also observe and document all load tests.

B. The Contractor shall provide the Engineer copies of installation records within 48 hours after each installation is completed. These installation records shall include, but are not limited to, the following information:

1. Name of project and Contractor
2. Name of Contractor's supervisor during installation
3. Date and time of installation
4. Name and model of installation equipment
5. Type of torque indicator used
6. Location of Helical Pile by grid location, diagram, or assigned identification number
7. Type and configuration of Lead Section with length of shaft and number and size of helical bearing plates
8. Type and configuration of Extension Sections with length and number and size of helical bearing plates, if any
9. Installation duration and observations
10. Total length installed
11. Final elevation of top of shaft and cut-off length, if any
12. Final plumbness or inclination of shaft
13. Installation torque at minimum three-foot depth intervals
14. Final installation torque
15. Comments pertaining to interruptions, obstructions, or other relevant information
16. Verified axial load capacity

C. If a load test fails the forgoing acceptance criteria, the Contractor shall modify the Helical Pile design and/or installation methods and retest the modified pile, as directed by the Pile Design Professional and the Engineer. These modifications include, but are not limited to, increasing the pile installation depth, increasing the minimum final installation

torque, increasing the quantity and or size of the helical blades. Any modifications of design or construction procedures, and any retesting required shall be at the Contractor's expense.

D. The Contractor shall provide the Engineer with copies of raw field load test data or reports within 24 hours after completion of each load test. Formal load test reports confirming configuration and construction details shall be provided to the Engineer within 7 days of completion of the load tests. This written documentation will either confirm the load capacity as required on the working drawings or propose changes based upon the results of the tests. At a minimum, the documentation shall include:

1. Name of project and Contractor
2. Date, time, and duration of test
3. Location of test Helical Pile by grid location, diagram, or assigned identification number
4. Test procedure (ASTM D1143, D3689, or D3966)
5. List of any deviations from procedure
6. Description of calibrated testing equipment and test set-up
7. Type and configuration of Helical Pile including lead section, number and type of extension sections, and manufacturer's product identification numbers
8. Load steps and duration of each load increment
9. Cumulative pile-head movement at each load step
10. Comments pertaining to test procedure, equipment adjustments, or other relevant information

3.8 CLEANUP

A. Within one week of completion of the work, the Contractor shall remove any and all material, equipment, tools, building materials, concrete forms, debris, or other items resulting from installation of Helical Piles.

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SECTION 32 12 16
ASPHALT PAVING

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. Hot-mix asphalt paving.

1.3 ACTION SUBMITTALS

A. Hot-Mix Asphalt Designs:

1. WisDOT approval of each hot-mix asphalt design proposed for the Work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For paving-mix manufacturer and testing agency. Paving subcontractor and testing firm shall be approved to work on WisDOT projects.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by Wis DOT.

B. Testing Agency Qualifications: Qualified in accordance with WisDOT for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of WisDOT or City of Madison standard specifications for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Tack Coat: Minimum surface temperature of 60 deg F.

2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D692/D692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. Fine Aggregate: ASTM D1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: ASTM D242/D242M, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: binder designation PG 58-28.

B. Tack Coat: ASTM D977 emulsified asphalt, or ASTM D2397/D2397M cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

C. Water: Potable.

2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled tires, asphalt shingles or glass from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by WisDOT and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: 3 MT 58-28 S.
3. Surface Course: 4 MT 58-28 S.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that base course is dry and in suitable condition to begin paving.

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

3.2 PREPARATION

A. Protection: Provide protective materials, procedures, and worker training to prevent asphalt materials from spilling, coating, or building up on curbs, driveway aprons, manholes, and other surfaces adjacent to the Work.

B. Proof-roll base course below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll base course in one direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.3 SURFACE PREPARATION

A. Ensure that prepared base course has been proof-rolled and is ready to receive paving. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces.

B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 HOT-MIX ASPHALT PLACEMENT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at a minimum temperature of 250 deg F.
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.

5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1½ inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method in accordance with AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.6 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to WisDOT density requirements:

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:

1. Surface Course: ¼ inch.

3.8 FIELD QUALITY CONTROL

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

B. In-Place Density: Perform density testing as required by WisDOT standard specifications.

C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION 32 12 16

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SECTION 32 13 13
CONCRETE PAVING

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. Sidewalks
2. Aprons
3. Driveways

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

A. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Fiber reinforcement.
3. Admixtures.
4. Curing compounds.
5. Bonding agent or epoxy adhesive.
6. Joint fillers.

B. Material Test Reports: For each of the following:

1. Aggregates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

C. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

1.7 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C 150, gray portland cement Type I. Supplement with the following, if desired:

    a. Fly Ash: ASTM C 618, Class C.
    b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S, uniformly graded. Provide aggregates from a single source.

1. Maximum Coarse-Aggregate Size: 1 inch (25 mm) nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: Potable and complying with ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.

2.3 FIBER REINFORCEMENT (OPTIONAL)

A. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C 1116/C 1116M, Type III, ½ to 1½ inches (13 to 38 mm) long.

2.4 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

B. White, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.

2.5 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.

2.6 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience. A previous mix design with performance history may be submitted.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 4000 psi (27.6 MPa).
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 6 percent plus or minus 1.5 percent for 1-inch (25-mm) or 3/4-inch nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture in concrete as required for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Ground Granulated Blast-Furnace Slag: 50 percent.
3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

G. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m).

2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

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

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting the building.

1. Extend joint fillers full width and depth of joint.
2. Terminate joint filler not less than ½ inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
3. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
4. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
5. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness.

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a ¼-inch (6-mm) radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

E. Edging: After initial floating, tool edges of paving and joints in concrete with an edging tool to a ¼-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from side forms. Use only square-faced shovels for hand spreading and consolidation.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

K. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Fog-spray forms and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture-retaining-cover curing or curing compound as follows:

1. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm) and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.
2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.8 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/8 inch (10 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus ¼ inch (6 mm).
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed ¼ inch (6 mm).
4. Contraction Joint Depth: Plus ¼ inch (6 mm), no minus.
5. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.9 FIELD QUALITY CONTROL

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

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one (1) composite sample for each separate placement location of each concrete mixture placed each day.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's placement of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's placement of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

    a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if compressive-strength tests equal or exceed specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

D. Test results shall be reported in writing to Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met.

F. Concrete paving will be considered defective if it does not pass tests and inspections.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

H. Prepare test and inspection reports.

3.10 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

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SECTION 32 13 73
CONCRETE PAVING JOINT SEALANTS

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. Hot-applied, fuel-resistant joint sealants.
2. Joint-sealant backer materials.
3. Primers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Paving-Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of joint sealant and accessory.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.6 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 HOT-APPLIED, FUEL-RESISTANT JOINT SEALANTS

A. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants: ASTM D 7116, Type I or Type II.

B. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants: ASTM D 7116, Type III.

2.3 JOINT-SEALANT BACKER MATERIALS

A. Round Backer Rods for Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.4 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:

1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.5 PAVING-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Fuel-resistant joints within concrete paving.

1. Joint Location:

   a. Expansion and isolation joints in concrete paving.
   b. Contraction joints in concrete paving.
   c. Other joints as indicated.

2. Joint Sealant: Fuel-resistant, multicomponent, pourable, modified-urethane, elastomeric joint sealant Hot-applied, fuel-resistant, single-component joint sealant.

END OF SECTION 32 13 73

SECTION 32 17 23
PAVEMENT MARKINGS

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. Painted markings applied to asphalt paving.
2. Painted markings applied to concrete surfaces.

1.3 ACTION SUBMITTALS

A. Product Data: Include technical data and tested physical and performance properties.

1. Pavement-marking paint, latex.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of WisDOT for pavement-marking work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.5 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain pavement-marking paints from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design.

2.3 PAVEMENT-MARKING PAINT

A. Pavement-Marking Paint, Latex: MPI #97, latex traffic-marking paint.

1. Color: Yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement-marking substrate is dry and in suitable condition to begin pavement marking in accordance with manufacturer's written instructions.

B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner.

B. Allow asphalt paving or concrete surfaces to age for a minimum of seven (7) days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to asphalt paving or concrete surface. Mask an extended area beyond edges of each stencil to prevent paint application beyond stencil. Apply paint so that it cannot run beneath stencil.

3.3 PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 32 17 23

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

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. Chain-link fences.

B. Related Requirements:

1. Refer to Section 03 30 00 "Cast-in-Place Concrete" regarding post footings.

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. Fence and posts, rails, and fittings.
b. Chain-link fabric, reinforcements, and attachments.
c. Accessories: Barbed wire.
d. Hardware.

B. Shop Drawings: For each type of fence assembly.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include accessories and hardware.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of chain-link fence.

1.5 FIELD CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.6 WARRANTY

A. Special Warranty: Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

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

    a. Failure to comply with performance requirements.
    b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: As indicated on Drawings.
2. Steel Wire for Fabric: Wire diameter of 0.148 inch.

    a. Mesh Size: 2 inches.
    b. Zinc-Coated Fabric: ASTM A392, Type II, Class 1, 1.2 oz./sq. ft. with zinc coating applied before weaving.

3. Selvage: Knuckled at both selvages.

2.2 FENCE FRAMEWORK

A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 based on the following:

1. Fence Height: As indicated on Drawings.
2. Light-Industrial-Strength Material: Group IC-L, round steel pipe, electric-resistance-welded pipe.
3. According to ASTM F1043, first two options in "Line Post" Subparagraph below are for both types of round pipe, third option is for Schedule 40 pipe only, and fourth option is for roll-formed-steel C-section shapes.

    a. Line Post: 1.9 inches in diameter.
    b. End, Corner, and Pull Posts: 2.375 inches.

4. Horizontal Framework Members: Top rails according to ASTM F1043.

    a. Top Rail: 1.66 inches in diameter.

5. Brace Rails: ASTM F1043.
6. Metallic Coating for Steel Framework:

    a. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.

7. Polymer coating over metallic coating.

a. Color: Match chain-link fabric, according to ASTM F934.

2.3 TENSION WIRE

A. Metallic-Coated Steel Wire: 0.177-inch- diameter, marcelled tension wire according to ASTM A817 or ASTM A824, with the following metallic coating:

1. Type II: Zinc coated (galvanized) by hot-dip process, with the following minimum coating weight:

a. Class 3: Not less than 0.8 oz./sq. ft. of uncoated wire surface.

B. Pipe and Tubing:

1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework.

C. Frame Corner Construction: Welded or assembled with corner fittings.

2.4 FITTINGS

A. Provide fittings according to ASTM F626.

B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive tension wire or top rail.

C. Rail and Brace Ends: For each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:

1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches long.

E. Tension and Brace Bands: Pressed steel.

F. Tension Bars: Steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.

G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

H. Tie Wires, Clips, and Fasteners: According to ASTM F626.

1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:

a. Hot-Dip Galvanized Steel: 0.106-inch- diameter wire**;** galvanized coating thickness matching coating thickness of chain-link fence fabric.

I. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz./sq. ft. of zinc.

a. Polymer coating over metallic coating.

2.5 GROUNDING MATERIALS

A. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for a review of property lines and legal boundaries**,** site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

1. Do not begin installation before final grading is completed unless otherwise permitted by Owner.

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

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

1. Install fencing on established boundary lines as staked.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 10 feet o.c.

F. Post Bracing and Intermediate Rails: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

G. Tension Wire: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:

1. Extended along bottom of fence fabric. Install bottom tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

H. Top Rail: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

I. Chain-Link Fabric: Apply fabric to the same side as the existing fence. Leave 2-inch bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 inches o.c.

K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric according to ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 24 inches o.c.

L. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

3.4 GROUNDING AND BONDING

A. Fence Grounding:

1. Install ground rods and connections at maximum intervals of 1500 feet.
2. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of 150 feet on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground according to IEEE C2 unless otherwise indicated.

D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

E. Connections:

1. Make connections with clean, bare metal at points of contact.
2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
4. Make above-grade ground connections with mechanical fasteners.
5. Make below-grade ground connections with exothermic welds.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

END OF SECTION 32 31 13

SECTION 32 91 13
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 specified by composition of the mixes.

B. Related Requirements:

1. Refer to Section 32 92 00 "Turf and Grasses" for turf and grasses.

1.3 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. Layered Soil Assembly: A designed series of planting soils, layered on each other that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. 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.

J. 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."

K. Planting Soil: Existing, on-site 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.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. 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.

O. 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.

P. 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.

Q. USCC: U.S. Composting Council.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include test data substantiating that products comply with requirements.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

1.6 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, provide testing by the following, or approved equal:

a. University of Wisconsin Soil Testing Laboratories, 8452 Mineral Point Road, Verona, WI 53593; (608) 262-4364.

2. All topsoil testing and re-testing shall be performed by a single laboratory.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil stripped during Site Clearing operations and/or any imported topsoil intended for use on the site.

B. Preconstruction Soil Analyses: For each unamended soil stockpile source, 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. Follow all guidelines indicated in publication from UW-Madison Soil Testing Laboratory called “Sampling Instructions”.
2. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.
3. Provide report results for Landscape Category L2, “Lawn, New from Seed”.
4. Include request for additional testing for the following tests: Lead (Pb), Soluble Salts, Physical Analysis (% sand, silt & clay) and Heavy Metals.

1.8 SOIL-SAMPLING REQUIREMENTS

A. General: Collect and process soil samples in accordance with UW-Madison Publication A2166 “Sampling Lawn and Garden Soils for Soil Testing”.

B. Clearly label all samples with a number and a location, corresponding to each separate stockpile or topsoil source. Provide to the laboratory for testing a single, uniform sample for each topsoil stockpile on-site and/or for each off-site source or location.

C. Submit the test results to the Architect for review and approval before using any of the topsoil on this project.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Topsoil: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site or off-site locally sourced topsoil material. Topsoil shall be clean salvaged or imported material capable of passing the ½” sieve and meeting the requirements of Section 625.2(1) of the Standard Specifications for Highway Construction. The material shall be free of rocks, gravel, wood, debris, and of noxious weeds and their seeds.

B. Topsoil testing results shall also indicate that topsoil falls within the following acceptable ranges and/or can be easily amended to produce topsoil conforming to the following requirements:

1. Final pH between 6.0-7.2
2. USDA classification loam, sandy loam, clay loam
3. Phosphorous (P) between 6-10ppm
4. Potassium (K) between 51-100 ppm
5. Organic Matter between 5-8%

6. C:N Ratio between 12:1 to 15:1
7. Soluble Salts in the range of 0-2 dS/m
8. Moisture Capacity of greater than 15%
9. Heavy Metals acceptable ranges are as follows:

    a. Cd 0.01-3.0 ppm
    b. Co 1.0-40.0 ppm
    c. Cr 5.0-1000.0 ppm
    d. Cu 2.0-100.0 ppm
    e. Fe 10000-50000 ppm
    f. Mn 100-4000 ppm
    g. Mo 0.5-40.0 ppm
    h. Ni 1.0-200.0 ppm
    i. Pb 2.0-200.0 ppm
    j. Zn 10-300 ppm
    k. Li 1.2 – 90.0 ppm

C. Topsoils falling outside of the ranges of acceptability that are not easily amended and/or contain high amounts of soluble salts or heavy metals will be rejected for use on this project.

2.2 PLANTING SOIL MIXTURE

A. Topsoil (imported or suitable stockpiled topsoil) and amendment mixture for use in all planting beds and for all areas to be seeded as indicated on drawings:

1. 2 parts topsoil
2. 1 part compost
3. 1 part sand
4. Other amendments and fertilizers as recommended by the soil test results, to adjust pH, or as specified in “Turfs and Grasses” Section.

B. Thoroughly blend planting soil mix before spreading.

C. Final pH of 6.5-7.2.

D. Final planting soil mix is subject to approval by Owner’s Representative.

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, 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 C 33/C 33M.

2.4 ORGANIC SOIL AMENDMENTS

A. Peat Moss: Type 1 sphagnum, weed and seed free, pH 3.1-5.0.

B. Leaf Compost: Screened and free of trash and other debris.

C. Compost: In compliance with WDNR Specification S100.

PART 3 - EXECUTION

3.1 GENERAL

A. Place topsoil the following depth: Lawn seeding areas 6”.

B. Place planting soil mixture at the following depth: Planting beds 18”.

C. 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.

D. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply topsoil on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till or disc subgrade to a minimum depth of 4 inches in any dimension and remove sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Mix thoroughly into top 2 inches of subgrade.

C. Mixing: Spread remainder of topsoil to total depth 6 inches, 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: Add any soil amendments necessary to produce satisfactory topsoil blend and mix approximately half the thickness of unamended topsoil over prepared, loosened subgrade.

D. Compaction: Compact each blended lift of planting soil to 75 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.

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. 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.

B. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by 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. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 32 91 13

SECTION 32 92 00
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. Lawn Seeding.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. 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 includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. 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.

D. 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 32 91 13 "Soil Preparation" for topsoil requirements to produce acceptable planting soils.

E. 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.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

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.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Five years' experience in turf installation.
3. Pesticide Applicator: State licensed, commercial.

1.6 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. 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.

1.7 FIELD CONDITIONS

A. Seeding Restrictions: Seed during one of the following periods. Coordinate seeding periods with initial maintenance periods to provide required maintenance from date of seeding completion.

1. Spring Seeding: April 1 to June 15.
2. Fall Seeding: September 1 to October 15.

B. Weather Limitations: Proceed with seeding only when existing and forecasted weather conditions permit seeding to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.8 MAINTENANCE

A. Initial Lawn Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in this Section. Begin maintenance immediately after seeding completion and continue until acceptable turf is established but for not less than the following periods:

1. Seeded Turf: 60 days from date of substantial completion or project acceptance, whichever is later.
2. When initial maintenance period has not elapsed before end of seeding season, or turf is not fully established, continue maintenance during the next seeding season.

1.9 GUARANTEE

A. The contractor shall guarantee the germination of seed installed during the regular seeding seasons.

B. If seeding occurs late in the season and germination cannot be guaranteed, Contractor shall work to provide erosion control and prevention coverage for any and all bare soil areas over winter and shall re-seed in the spring.

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: State-certified seed of grass species as follows:

1. Lawn Seeding: Reference Bid Package A Seed Mix

a. Composition Proportions by weight:

1) Baron bluegrass: 20%
2) Majestic bluegrass 20%
3) Touchdown bluegrass 20%
4) Pennlawn fescue 20%
5) Fiesta rye grass 20%
6) Or approved equal

2. Contractor may submit alternate blends for review but approval will be based on similarity to the blends outlined above. Approval of any alternates is at the sole discretion of the Landscape Architect.

2.2 FERTILIZERS

A. Lawn: All fertilizer shall be a commercial balanced 16-8-8 fertilizer delivered to the site in bags labeled with the Manufacturer's guaranteed analysis.

B. Special protection: If stored at the site, protect fertilizer from the elements at all times.

2.3 MULCHES

A. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.

2.4 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within seeded areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive seed for compliance with requirements and conditions affecting installation and performance.

1. It is the responsibility of the Landscape Contractor to verify that sufficient Planting Soil has been provided both in terms of quality and quantity (depths) as indicated in Section 32 91 13 “Soil Preparation”. If insufficiencies in planting soil occur, Landscape Contractor shall notify Landscape Architect and General Contractor immediately and shall not begin any seeding operations until any and all unsatisfactory conditions have been corrected.
2. 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 lawn area.
3. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed and replace with new planting soil.

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by seeding operations.

1. Protect grade stakes set by others until directed to remove them.

3.3 FERTILIZING

A. Apply the specified fertilizer at the rate of 10 pounds per 1,000 square feet, raking lightly into the soil.

3.4 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or 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 Lawn at a total rate of 5 lb/1000 sq. ft min.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with erosion-control blankets and mats where indicated on Drawings; install and anchor according to manufacturer's written instructions.

E. Protect seeded areas that are not within areas of erosion control blankets or mats with compost mulch immediately after seeding. Lightly moisten seeded areas and scatter or spray mulch uniformly to a thickness of 3/16 inch and roll surface smooth, taking care not to displace seed or topsoil.

3.5 MAINTENANCE

A. Maintain and establish lawn by watering, weeding, mowing, trimming, reseeding, and performing other operations as required to establish healthy, viable stand of lawn. Roll, re-grade, and re-seed 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.

1. 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.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Seeded areas are to be watered daily to maintain adequate soil surface moisture for proper seed germination. Watering shall continue for not less than 30 days following seeding. Thereafter, apply ½" of water twice weekly until final acceptance.

1. 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 seeded areas.

C. Mowing: Lawns shall not be mowed shorter than four (4) inches at any mowing. The first mowing shall correspond to the time when the lawn has become fully established, vigorous, and robust.

D. Premature mowing of lawns can damage the seed bed. The contractor will be held fully responsible for evaluating the health and vigor of the lawn during all maintenance activities

and shall adjust maintenance practices, in consultation with Owner's Project Representative, to produce a healthy, vigorous and fully-established lawn by the end of the maintenance period.

E. Turf Postfertilization: Do not fertilize lawns unless specifically directed to do so by seed supplier.

F. The Contractor shall utilize organic methods and materials for applications to reduce pests or weeds (compost, etc). The use of any chemical pesticides or herbicides shall be approved by Owner prior to any applications on this site during installation or maintenance period

G. If chemical products are approved, apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

H. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

I. Contractor shall possess all training and certificates necessary to safely apply any and all pesticides and herbicides.

3.6 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

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.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.7 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.8 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 seeded areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after lawns are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 92 00

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SECTION 33 05 00
COMMON WORK RESULTS FOR UTILITIES

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:

1. Piping joining materials.
2. Transition fittings.
3. Sleeves.
4. Grout.
5. Flowable fill.
6. Piped utility demolition.
7. Piping system common requirements.
8. Equipment installation common requirements.
9. Painting.
10. Concrete bases.
11. Metal supports and anchorages.

1.3 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

B. Concealed 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.

C. ABS: Acrylonitrile-butadiene-styrene plastic.

D. CPVC: Chlorinated polyvinyl chloride plastic.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.4 QUALITY ASSURANCE

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

B. Steel Piping 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. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.5 DELIVERY, STORAGE, AND HANDLING

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

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

A. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

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

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

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series, 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/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 TRANSITION FITTINGS

A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings NPS 1-1/2 (DN 40) and Smaller:

1. Underground Piping: Manufactured piping coupling or specified piping system fitting.
2. Aboveground Piping: Specified piping system fitting.

C. AWWA Transition Couplings NPS 2 (DN 50) and Larger:

1. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

D. Plastic-to-Metal Transition Fittings:

1. Description: One-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint or threaded end.

E. Plastic-to-Metal Transition Unions:

1. Description: MSS SP-107, four-part union. Include threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

F. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of two subparagraphs and list of manufacturers below. See Section 01 60 00 "Product Requirements."

1. Description: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.3 SLEEVES

A. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

F. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.4 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.

2.5 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix.

1. Cement: ASTM C 150, Type I, portland.
2. Density: 115- to 145-lb/cu. ft.
3. Aggregates: ASTM C 33, natural sand, fine and crushed gravel or stone, coarse.
4. Aggregates: ASTM C 33, natural sand, fine.
5. Admixture: ASTM C 618, fly-ash mineral.
6. Water: Comply with ASTM C 94/C 94M.
7. Strength: 100 to 200 psig at 28 days.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

A. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING INSTALLATION

A. Install piping according to the following requirements and utilities 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 the Coordination Drawings.

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 to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

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

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Sleeves are not required for core-drilled holes.

J. Permanent sleeves are not required for holes formed by removable PE sleeves.

K. Install sleeves for pipes passing through concrete and masonry walls 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 equipment areas or other wet areas 2 inches above finished floor level.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

    a. Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).

b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

L. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

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

E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. 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 (0.20 percent maximum lead content) complying with ASTM B 32.

I. 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.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
5. PVC Nonpressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

N. Plastic 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 PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric fittings at connections of dissimilar metal pipes.

3.5 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.

C. Install equipment to allow right of way to piping systems installed at required slope.

3.6 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches 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 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

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to structural steel section.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.9 GROUTING

A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 33 05 00

SECTION 33 41 00
STORM UTILITY DRAINAGE 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. Pipe and fittings.
2. Inlets and Catch Basins.
3. Manholes

1.3 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Stormwater inlets, catch basins and manholes. Include plans, elevations, sections, details, frames, covers, and grates.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle stormwater inlets according to manufacturer's written rigging instructions.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of service.

2. Do not proceed with interruption of service without Owner's written permission.

PART 2 - PRODUCTS

2.1 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76.

1. Bell-and-spigot ends
2. Class III, Wall B.

B. Polypropylene storm sewer pipe shall conform to ASTM F2881 and AASHTO M330 and have a smooth interior and corrugated exterior

1. Pipes shall be joined with gasketed bell and spigot meeting the requirements of ASTM F2881. Gaskets shall conform to ASTM F477.
2. Fittings shall conform to ASTM F2881 and AASHTO M330 and ASTM F477.
3. Pipe shall be watertight and conform to ASTM D3212.
4. Polypropylene compound for the pipe shall be impact modified copolymer meeting the material requirements of ASTM F2881, Section 5 and AASHTO M330, Section 6.1.

C. PVC Pipe and Fittings

1. Cellular Core PVC Pipe: ASTM F 891, Schedule 80.
2. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 80 pipe.

2.2 INLETS AND CATCH BASINS

A. Standard Precast Concrete Catch Basins and Inlets:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
3. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
4. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
5. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. Designed Precast Concrete Catch Basins and Inlets: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for joint sealants.

1. Joint Sealants: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.

2. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
3. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

C. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for HS 20, structural loading.

1. Size: 36” round grate opening – see detail on drawings.

2.3 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
5. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
6. Steps: ASTM A 615/A 615M, deformed, ½ inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
7. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 31 20 00 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

3.3 POLYPROPYLENE PIPE

A. Install polypropylene and PVC pipe according to ASTM D2321 and manufacturer's recommendations.

B. Minimum cover over pipe shall be 1.5 feet.

3.4 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
2. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.5 CATCH BASIN AND INLET INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.6 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements with a minimum of 4-inches of adjustment. Set tops 3 inches above finished surface elsewhere unless otherwise indicated.

3.7 CONNECTIONS

A. Make connections to existing piping and underground manholes.

1. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION 33 41 00

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