PROJECT MANUAL

STATE STREET CAMPUS GARAGE MIXED-USE, PHASE 1

415 N. LAKE STREET
MADISON, WI 53715

CONSTRUCTION DOCUMENTS

milwaukee : 333 E Chicago St
madison : 309 W Johnson St, Ste 202
green bay : 124 N Broadway
denver : 1899 Wynkoop St, Ste 700
atlanta : 1401 Peachtree St NE, Ste 300

EUA PROJECT NUMBER: **720448**
BPW CONTRACT #: **9361**

DATE: 10-02-2023

VOLUME 2

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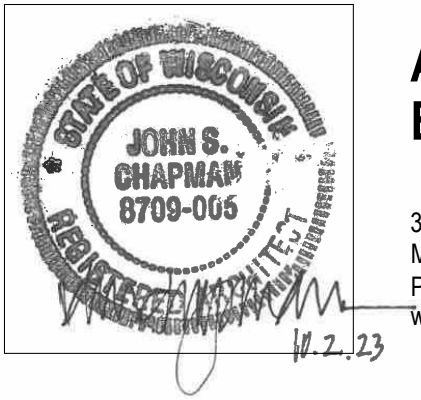
SEALS PAGE



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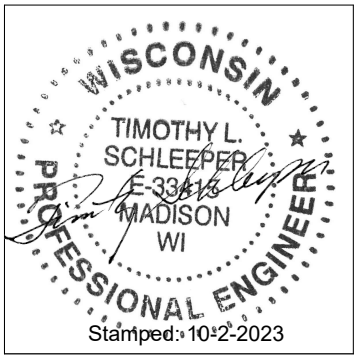

CIVIL
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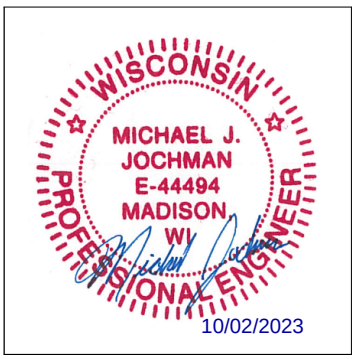

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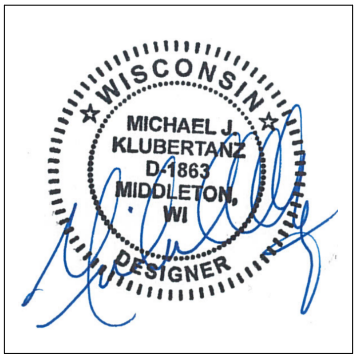

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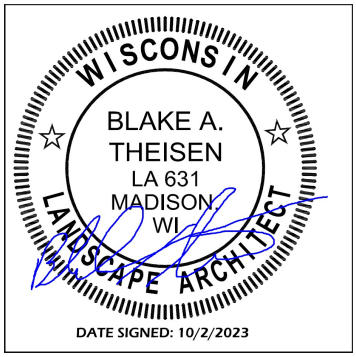

LANDSCAPE ARCHITECT
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SECTION 21 05 00

COMMON WORK REQUIREMENTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.01 SUMMARY

A. 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.

1.02 REGULATORY REQUIREMENTS

A. Codes and Standards:

1. All Fire Suppression work shall conform to the requirements of Wisconsin Building Code (COMM) and City of Madison Fire Department, NFPA Standards, and local regulations regarding design, materials, and installation.
2. All materials and workmanship shall comply with applicable Codes, local ordinances, industry standards and utility regulations. In case of differences between such Codes, and the Contract Documents, the most stringent shall govern. Promptly notify the A/E in writing of any such difference.

B. Non-Compliance:

1. Should the Contractor perform any work that does not comply with the above requirements, without having notified the A/E, he shall bear all costs necessary to correct the deficiencies.

C. Permits, Inspections and Fees:

1. All required, permits, and inspections shall be requested and obtained by the Contractor.
2. All fees and charges for approvals, reviews, or other inspections shall be paid by the Contractor.
3. All fees and charges assessed by local utilities for water, sewer, gas or other services shall be included in the bid and shall be paid by the Contractor(s).

1.03 REFERENCE STANDARDS

A. Standards cited in the Specifications shall be the most recent editions.

B. Abbreviations of standards organizations referenced in this, and other sections are as follows:

1. AGA American Gas Association
2. ANSI American National Standards Institute
3. ASME American Society of Mechanical Engineers
4. ASPE American Society of Plumbing Engineers
5. ASTM American Society for Testing and Materials
6. AWWA American Water Works Association

7.	AWS	American Welding Society
8.	CGA	Compressed Gas Association
9.	CS	Commercial Standards, Products Standards Sections, Office of Engineering Standards Service, NBS
10.	DSPS	State of Wisconsin Department of Professional Services
11.	EPA	Environmental Protection Agency
12.	FM	Factory Mutual System
13.	FS	Federal Specifications, Superintendent of Documents, U.S. Government Printing Office
14.	IAPMO	International Association of Plumbing & Mechanical Officials
15.	IEEE	Institute of Electrical and Electronics Engineers
16.	ISA	Instrument Society of America
17.	MCA	Mechanical Contractors Association
18.	MICA	Midwest Insulation Contractors Association
19.	MSS	Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc.
20.	NBS	National Bureau of Standards
21.	NEC	National Electric Code
22.	NEMA	National Electrical Manufacturers Association
23.	NFPA	National Fire Protection Association
24.	UL	Underwriters Laboratories Inc.

1.04 QUALITY ASSURANCE

A. The Contractor must submit for pre-approval of any substitutions or equals 5 days prior to bid date.

B. All products and materials used are to be new, undamaged, clean and in good condition. Existing products and materials are not to be reused unless specifically indicated.

C. 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 for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

1.05 ABBREVIATIONS AND SYMBOLS

A. Key to abbreviations and symbols shall be on the Drawings.

B. The following are additional abbreviations used in the Specifications:

1.	A/E	Architect/Engineer
2.	GC	General Contractor
3.	PC	Plumbing Contractor
4.	FPC	Fire Protection Contractor
5.	HC	Heating Ventilating and Air Conditioning Contractor
6.	EC	Electrical Contractor

1.06 DEFINITIONS

A. Furnish: Supply and deliver to Project site ready for unpacking, assembly, and installation.

B. Install: Operations at Site including unpacking, assembling, erecting, placing, anchoring, applying, finishing, cleaning, and connecting related devices required for product fully functional for intended use after installation.

C. Provide: Furnish and install, such that product is fully functional for intended use.

1.07 COORDINATION

A. The Drawings show the general arrangement of piping and equipment and shall be followed as closely as actual building construction and the work of other trades permits. Architectural and Structural Drawings shall take precedence. Because of the scale of the Drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate conditions affecting the Work and arrange accordingly, providing offsets, fittings and accessories as may be required to meet conditions.

1.08 SEALING AND FIRESTOPPING

A. Sealing and firestopping of sleeves/openings between piping, etc. and the sleeve or structural opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

1.09 EQUIPMENT FURNISHED BY OTHERS

A. Drawings indicate equipment to be furnished or installed by Others. When providing utility connections, coordinate exact requirements, including quantity, location, elevation size, material, flow, and pressure.

1.10 SUBMITTALS

A. Refer to Division 1, General Conditions, Submittals.

B. Submit the following fire suppression system data sheet for approval by the GC and A/E. List piping material type for each piping service on the project, ASTM number, schedule or pressure class, joint type, manufacturer, and model number where appropriate. List valves and specialties for each piping service, fixture and equipment with manufacturer and model number.

C. Shop drawing submittals are to be bound, labeled, contain the project manual cover page and a material index list page showing item designation, manufacturer and additional items supplied with the installation. 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 and/or number, as indicated in the contract documents. Include wiring diagrams of electrically powered equipment.

D. Submit electronic (PDF) copy of all submittals for review by A/E, Architect, Owner, Owners Representative and Building Operator.

1.11 EQUIPMENT INSTALLATION

A. Drawings show general arrangement and location of equipment and appurtenances. It is Contractor's responsibility to install equipment in a location and manner that allows for proper service and maintenance access to equipment. Work shall generally conform to requirements shown on Drawings. However, location of equipment may require field adjustments to obtain required service space. DO NOT SCALE OFF PLANS to determine proper location of equipment. Because of scale of Drawings, it is not possible to indicate exact routing of piping, and offsets, fittings and accessories required to provide proper service access to equipment. Contractor shall route and install ductwork and piping to provide required service access to equipment.

B. If, during construction phase of Project, contractor feels inadequate space exists, or equipment locations must be substantially modified to provide proper service and maintenance access, prior to installing equipment, contractor shall notify engineer in writing, outlining general concerns and proposed modifications. Equipment installed without providing manufacturer's required maintenance and service clearance shall be considered defective. Contractor shall remove and relocate piping, ductwork and equipment, to provide required service clearances at contractor's expense.

1.12 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Assemble material in three-ring or post binders, using an index at the front of each volume and tabs for each system or type of equipment. In addition to the data indicated in the General Requirements, include the following information:

1. Copies of all approved shop drawings.
2. Manufacturer's wiring diagrams for electrically powered equipment
3. Records of tests performed to certify compliance with system requirements.
4. Certificates of inspection by regulatory agencies
5. Parts lists for fixtures, equipment, valves, and specialties.
6. Manufacturer's installation, operation and maintenance recommendations for fixtures, equipment, valves, and specialties.
7. Valve schedules
8. Lubrication instructions, including list/frequency of lubrication.
9. Warranties
10. Additional information as indicated in the technical specification sections.

1.13 RECORD DRAWINGS

A. Maintain Record Drawings on daily basis to be turned over at completion of Project.

1.14 TRAINING OF OWNER PERSONNEL

A. Instruct Owner's personnel in proper operation and maintenance of systems and equipment provided as part of Project, using Operating and Maintenance manuals during instruction. Demonstrate startup, shutdown, and maintenance procedures for equipment.

B. Training shall be video recorded and shall occur during normal working hours.

1.15 TESTING

A. Provide materials, labor, and equipment required for testing.

B. Notify Inspector(s) one day prior to the time when the test is ready to be performed.

C. After testing, submit in writing the time, date, name, and title of the person approving the test. This shall also include the description and what portion of the system has been tested. The person approving the test shall sign the submittal.

D. Records shall be maintained of testing that has been completed and shall be made available at the job site.

E. Upon completion of the work, records and certifications approving testing requirements shall be submitted.

F. Defective work or material shall be replaced or repaired, and the test repeated. Repairs shall be made with new materials.

1.16 CLEANING

A. Keep the premises broom clean and free of surplus materials, rubbish, and debris.

B. After fixtures and equipment have been installed, remove stickers, rust stains, labels, and temporary covers.

C. Foreign matter shall be blown out, or flushed out, of pipes, tanks, pumps, strainers, motors, devices, switches, fixtures, and panels.

D. Identification plates on equipment shall be free of paint and dirt.

E. Leave the work in a condition ready for operation.

1.17 WARRANTY

A. Warrant that work shall function for one year immediately following acceptance of the system(s).

B. Keep the system in good working order at no expense, unless defects are clearly the result of improper or abnormal usage.

C. Submit for acceptance of the work, written certification that the entire system has been installed and adjusted for operation in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 IDENTIFICATION

A. Stencils

1. Not less than 1 inch high letters/numbers for marking pipe and equipment.

B. Snap-On Pipe Markers

1. Cylindrical self-coiling plastic sheet that snaps over piping insulation and is held tightly in place without the use of adhesive, tape or straps. Not less than 1 inch high letters/numbers and flow direction arrows for piping marking. W. H. Brady, Seton, Marking Services, or equal.

C. Engraved Name Plates

1. White letters on a black background, 1/16 inch thick plastic laminate, beveled edges, screw mounting, Setonply Style 2060 by Seton Name Plate Company or Emedolite- Style EIP by EMED Co., or equal by Marking Services, or W. H. Brady.

PART 3 - EXECUTION

3.01 DEMOLITION

A. Perform all demolition as indicated on the drawings to accomplish new work. Where demolition work is to be performed adjacent to existing work that remains in an occupied area, construct temporary dust partition to minimize the amount of contamination of the occupied space. Where piping is removed and not reconnected with new work, cap ends of existing services as if they were new work. Coordinate work with the user agency to minimize disruption to the existing building occupants.

B. All pipe, wiring and associated conduit, insulation, ductwork, and similar items demolished, abandoned, or deactivated are to be removed from the site by the Contractor. All piping specialties are to be removed from the site by the Contractor unless they are dismantled and removed or stored by the user agency. All designated equipment is to be turned over to the user agency for their use at a place and time so designated. Maintain the condition of material and/or equipment that is indicated to be reused equal to that existing before work began.

3.02 GENERAL

A. Coordination of Work:

1. Review the complete set of Drawings and Specifications and report discrepancies to the A/E. Obtain written instructions for changes necessary. Coordinate with each trade prior to beginning installation and make provisions to avoid interferences. Changes required caused by neglect to coordinate shall be made without expense to the project.
2. Piping shall not be located above electrical panels.

B. Anchor Bolts, Sleeves, and Supports:

1. These items required for the Work shall be furnished by the FPC for proper installation of his work. They shall be installed (except as otherwise specified) by the trade furnishing and installing the material in which they are to be located. Location of anchor bolts, sleeves, inserts and supports shall be directed by the trade requiring them. Expense resulting from the improper location or installation of anchor bolts, sleeves, inserts and supports shall be paid for by the Contractor for the trade with responsibility for directing their proper location.

C. Adjustments in Locations:

1. Locations of pipes and equipment shall be adjusted to accommodate the work interferences anticipated and encountered. Prior to fabrication determine the exact route and location of each pipe (subject to A/E's approval).

D. Right Of Way:

1. New lines which pitch shall have the right of way over those which do not pitch. For example: Gravity drains shall normally have right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed. Notify A/E and other trades of conflicts.
2. Offsets, transitions, and changes in direction of electrical raceways, pipes, and ducts shall be made to maintain proper room and pitch of sloping lines whether or not indicated on the Drawings.

3.03 CUTTING AND PATCHING

A. Provisions for openings including chases, holes and clearances through walls, floors, and roof, ceilings and partitions shall be made in advance of construction of each part of the building. Openings shall be provided by the GC for the respective materials in which openings occur, during the construction of the building with the exception of pipe sleeves. The FPC shall furnish to the GC opening dimensions and locations.

B. If the FPC neglects to inform the GC of his opening requirements before that portion of the building construction is complete, the FPC shall cut the openings and provide framing and lintels. In the event holes must be cut through reinforced concrete, avoid spalling and unnecessary damage or weakening of structural members. No chopping or breaking out is permitted. Before cutting or drilling, obtain permission from the A/E. Patch adjacent materials and repair damage resulting from the cutting.

3.04 BUILDING ACCESS

A. Arrange for necessary openings in building to allow for admittance of all apparatus. When building access was not previously arranged and must be provided by Contractor, restore opening to original condition after the apparatus has been brought into building. Coordinate with Architect/Engineer.

3.05 EQUIPMENT ACCESS

A. Install piping, conduit, fixtures, and accessories to permit access to equipment for maintenance. Coordinate exact location of wall and ceiling access panels and doors with General Contractor, making sure access is available for equipment and specialties. Where access is required in plaster walls or ceilings, furnish and install access doors required. Coordinate for installation of access doors utilizing General Contractor and other appropriate on-site subcontractor for access door installation.

B. Accessible ceilings, (i.e., lay-in ceilings) do not require access panels. Provide color coded thumb tacks or screws, depending on surface, for use in accessible ceilings.

3.06 COORDINATION OF WORK

A. Install systems, equipment, and piping in cooperation with other trades. Locations of pipes, equipment, fixtures, etc., shall be adjusted to accommodate the work interferences anticipated and encountered. Prior to fabrication determine the exact route and location of each pipe (subject to A/E's approval).

B. Any work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

C. Verify that all devices are compatible for the type of construction and surfaces on which they will be used.

D. Offsets, transitions, and changes in direction of electrical raceways, pipes and ducts shall be made as required to maintain proper room and pitch of sloping lines whether or not indicated on the Drawings. Furnish and install all traps, air vents, sanitary vents, etc., as required to affect the offsets, transitions, and changes in direction.

E. New lines which pitch shall have the right of way over those which do not pitch. For example: Gravity drains shall normally have right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed. Notify A/E and other trades of any conflicts.

F. Provide appropriate sections of work with required wall, roof and floor opening locations and dimensions. If Contractor neglects to coordinate information, openings shall be the responsibility of Contractor.

3.07 PIPING INSTALLATION

A. General:

1. Expansion and contraction of piping shall be provided for by expansion loops, bends, swing joints, or expansion joints to prevent damage to connections, piping, equipment of the building.
2. Unions or flanges shall be installed on all by-passes, ahead of all traps, adjacent to screw connection valves, and at all connections to equipment, whether or not shown on drawings.

B. Installation Arrangement:

1. Install all Work to permit removal (without damage to other parts) of all parts requiring periodic replacement or maintenance. Arrange pipes and equipment to permit ready access to valves, cocks, traps, starters, motors, control components and to clear the openings of swinging and overhead doors and of access panels.

C. Connections Different from Those Shown:

1. Where equipment requiring different arrangement or connections from those shown is used, install the equipment to operate properly and in harmony with the intent of the Drawings and Specifications. When requested by the A/E, submit drawings showing the proposed installation.
2. If the proposed installation is approved, make all incidental changes in piping, ductwork, supports, insulation, wiring, panelboards, etc. Provide any additional motors, controllers, valves, fittings and other additional equipment required for the proper operation of the system resulting from the selection of equipment, including all required changes in affected trades. The Contractor shall be responsible for the proper location of rough in and connections by other trades.
3. All changes shall be made at no increase in the Contract amount or additional cost to the other trades.

END OF SECTION 21 05 00

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SECTION 21 05 17

SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves without waterstop.
2. Sleeves with waterstop.
3. Sleeve-seal systems.
4. Grout.
5. Silicone sealants.

1.2 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

C. Steel Sheet Sleeves: ASTM A653/A653M, 0.0239-inch minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.

2.2 SLEEVES WITH WATERSTOP

A. Description: Manufactured steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

2.3 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Designed to form a hydrostatic seal of 20 psig minimum.
2. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with ASTM B633 coating of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000 psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.

1. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.

B. Silicone, S, P, T, NT: Single-component, 25, pourable, movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant.

1. Standard: ASTM C920, Type S, Grade P, Class 25, Uses T and NT.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

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.
2. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 84 13 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout or silicone sealant, seal space around outside of sleeves.

3.3 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building and passing through exterior walls.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
2. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.5 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above and below Grade:
   a. Sleeves with waterstops.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
2. Concrete Slabs-on-Grade:
   a. Sleeves with waterstops.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
   a. Sleeves with waterstops.
4. Interior Walls and Partitions:
   a. Sleeves without waterstops.

END OF SECTION 21 05 17

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SECTION 21 05 18

ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.2 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

1. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
   b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel with polished, chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.

f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:
   a. Chrome-Plated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
   b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
   c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

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

1. New Piping: Split floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 21 05 18

SECTION 21 05 23

GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron butterfly valves with indicators.
2. Check valves.
3. Iron OS&Y gate valves.
4. NRS gate valves.
5. Indicator posts.
6. Trim and drain valves.

1.2 SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Fire Main Equipment: HAMV - Main Level.
   a. Indicator Posts, Gate Valve: HCBZ - Level 1.
   b. Ball Valves, System Control: HLUG - Level 3.
   c. Butterfly Valves: HLXS - Level 3.
   d. Check Valves: HMER - Level 3.
   e. Gate Valves: HMRZ - Level 3.
2. Sprinkler System and Water Spray System Devices: VDGT - Main Level.
   a. Valves, Trim and Drain: VQGU - Level 1.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:
   a. Indicator posts.
   b. Valves.
      1) Gate valves.
      2) Check valves
      3) Miscellaneous valves.

C. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.

2. ASME B16.1 for flanges on iron valves.
3. ASME B31.9 for building services piping valves.

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

E. NFPA Compliance for valves:

1. Comply with NFPA 13, NFPA 14, NFPA 20, and NFPA 24.

F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher, as required by system pressures.

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

H. Valve Actuator Types:

1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.3 IRON BUTTERFLY VALVES WITH INDICATORS

A. Manufacturers: Ames, Grinnell, Nibco, TYCO, Victaulic, or Wilkins.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, nickel plated.
7. Actuator: Worm gear.
8. Supervisory Switch: Internal or external.
9. Body Design: Grooved-end connections.

2.4 CHECK VALVES

A. Manufacturers: Ames, Grinnell, Nibco, TYCO, Victaulic, or Wilkins.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.5 IRON OS&Y GATE VALVES

A. Manufacturers: Ames, Grinnell, Nibco, TYCO, Victaulic, or Wilkins.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze.
5. Wedge Seat: Cast or ductile iron, or bronze.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged or grooved.

2.6 NRS GATE VALVES

A. Manufacturers: Ames, Grinnell, Nibco, TYCO, Victaulic, or Wilkins.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron.
5. Wedge Seat: Cast or ductile iron, or bronze.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged or grooved.

2.7 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Manufacturers: Grinnell, Nibco, or TYCO.

2. Description:
   a. Pressure Rating: 250 psig.
   b. Body Design: Two piece.
   c. Body Material: Forged brass or bronze.
   d. Port size: Full or standard.
   e. Seats: PTFE.
   f. Stem: Bronze or stainless steel.
   g. Ball: Chrome-plated brass.
   h. Actuator: Handlever.
   i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
   j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:

1. Manufacturers: Grinnell, Nibco, TYCO, or Victaulic.

2. Description:
   a. Pressure Rating: 250 psig.
   b. Body Material: Brass or bronze.
   c. Ends: Threaded.
   d. Stem: Bronze.
   e. Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

1. Manufacturers: Grinnell, Nibco, TYCO, or Victaulic.

2. Description:
   a. Pressure Rating: 250 psig.
   b. Body Material: Bronze with integral seat and screw-in bonnet.
   c. Ends: Threaded.
   d. Stem: Bronze.
   e. Disc Holder and Nut: Bronze.
   f. Disc Seat: Nitrile.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with requirements in the following Sections for specific valve-installation requirements and applications:

1. Section 21 13 13 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
2. Section 21 13 16 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.

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. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

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

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

F. Install valve tags. Comply with requirements in Section 21 05 00 "Common Work Requirements for Fire Suppression" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

END OF SECTION 21 05 23

SECTION 21 05 29

HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 05 50 00 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations.

C. Welding certificates.

1.3 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

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

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

C. NFPA Compliance: Comply with NFPA 13.

D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe and Tube Hangers:

1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 TRAPEZE PIPE HANGERS

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

2.4 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or Stainless steel.
2. Outdoor Applications: Stainless steel.

2.5 EQUIPMENT SUPPORTS

A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.6 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout, suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. 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 A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

D. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

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

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

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

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

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

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

L. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

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

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

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

3.5 ADJUSTING

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

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

3.6 HANGER AND SUPPORT SCHEDULE

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

B. Comply with NFPA requirements 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 finishes.

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

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

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Comply with NFPA requirements.

K. Building Attachments: Comply with NFPA requirements. 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. C-Clamps (MSS Type 23): For structural shapes.
3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

L. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

M. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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

END OF SECTION 21 05 29

SECTION 21 11 19

FIRE DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flush-type fire-department connections.

1.2 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 fire-department connection.

PART 2 - PRODUCTS

2.1 FLUSH-TYPE FIRE-DEPARTMENT CONNECTION

A. Manufacturers: Badger-Powhatan, Croker, Elkhart Brass, J.W. Moon, Potter-Roemer, and W.D. Allen.

B. Standard: UL 405.

C. Type: Flush, for wall mounting.

D. Pressure Rating: 175 psig minimum.

E. Body Material: Corrosion-resistant metal.

F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

G. Caps: Brass, lugged type, with gasket and chain.

H. Escutcheon Plate: Rectangular, brass, wall type.

I. Outlet: With pipe threads.

J. Body Style: Horizontal.

K. Number of Inlets: Six.

L. Outlet Location: Back.

M. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."

N. Finish: Polished chrome plated, coordinate with architect.

O. Outlet Size: NPS 8.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wall-type fire-department connections.

B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 21 11 19

SECTION 21 13 13

WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Copper tube and fittings.
3. Cover system for sprinkler piping.
4. Air vent.
5. Sprinkler piping specialties.
6. Specialty valves.
7. Sprinklers.
8. Manual control stations.
9. Pressure gauges.

B. Related Requirements:

1. Section 21 11 19 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

D. Coordination Drawings: Sprinkler system plans and sections, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

E. Qualification Data: For qualified Installer and professional engineer and NICET certified technician.

F. Design Data: Approved sprinkler piping working plans, prepared according to NFPA 13, including documented approval by authorities having jurisdiction, and including hydraulic calculations if applicable.

G. Field Test Reports: 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."

H. Field quality-control reports.

I. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
   a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by qualified professional engineer or NICET certified technician, "Water-Based Systems Layout."

PART 2 - PRODUCTS

2.1 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.

B. Sprinkler system equipment, specialties, accessories, installation, and testing to comply with NFPA 13.

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

D. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design wet-pipe sprinkler systems.

1. Available fire-hydrant flow test records indicate the following conditions:
   a. Estimated Model Results by: City of Madison.
   b. Static Pressure at Residual Fire Hydrant R: 67 psig.
   c. Measured Flow at Flow Fire Hydrant F: 1500 gpm.
   d. Residual Pressure at Residual Fire Hydrant R: 47 psig.
2. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
3. Sprinkler Occupancy Hazard Classifications:
   a. Automobile Parking and Showrooms: Ordinary Hazard, Group 2.
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. Elevator Machine Room and Hoistway: Ordinary Hazard, Group 1.
   d. Exterior and Interior Loading Docks, Handling Flammable/Combustible Liquids, Hazardous Materials, or Utilized for Storage: Ordinary Hazard Group 1.
   e. General Storage Areas: Ordinary Hazard, Group 1.
   f. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   g. Offices, including Data Processing: Light Hazard.
4. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm/sq. ft. over 1500 sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm/sq. ft. over 1500 sq. ft. area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm/sq. ft. over 1500 sq. ft. area.
5. Maximum protection area per sprinkler according to UL listing.
6. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq. ft.
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

E. Obtain documented approval of sprinkler system design from authorities having jurisdiction.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 40 Standard-Weight Steel Pipe: Galvanized- and black-steel pipe, ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 10 and smaller; and NFPA 13-specified wall thickness in NPS 2 and larger, plain end.

C. Steel Pipe Nipples: Galvanized- and black-steel pipe, ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

D. Steel Couplings: Galvanized and uncoated steel, ASTM A865/A865M, threaded.

E. Gray-Iron Threaded Fittings: Galvanized and uncoated gray-iron threaded fittings, ASME B16.4, Class 125, standard pattern.

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

G. Cast-Iron Flanges: ASME 16.1, Class 125.

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

1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick.
   a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
   b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

I. Grooved-Joint, Steel-Pipe Appurtenances:

1. Pressure Rating: 250-psig minimum.
2. Grooved-End Fittings for Steel Piping: Painted grooved-end fittings, ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Specialty Valves Pressure Rating: 175-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Alarm Valves:

1. Standard: UL 193.
2. Design: For horizontal or vertical installation.

3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, and fill-line attachment with strainer.
4. Drip cup assembly pipe drain without valves and separate from main drain piping.

G. Automatic (Ball Drip) Drain Valves:

1. Standard: UL 1726.
2. Pressure Rating: 175-psig minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4.
5. End Connections: Threaded.

2.4 AIR VENT

A. Manual Air Vent/Valve:

1. Description: Ball valve that requires human intervention to vent air.
2. Body: Forged brass.
3. Ends: Threaded.
4. Minimize Size: 1/2 inch.
5. Minimum Water Working Pressure Rating: 300 psig.

B. Automatic Air Vent:

1. Description: Automatic air vent that automatically vents trapped air without human intervention.
2. Standard: UL listed or FM Global approved for wet-pipe fire sprinkler systems.
3. Vents oxygen continuously from system.
4. Float valve to prevent water discharge.
5. Minimum Water Working Pressure Rating: 175 psig.

C. Automatic Air Vent Assembly:

1. Description: Automatic air vent assembly that automatically vents trapped air without human intervention, including Y-strainer and ball valve in a prepiped assembly.
2. Standard: UL listed or FM Global approved for use in wet-pipe fire sprinkler system.
3. Vents oxygen continuously from system.
4. Float valve to prevent water discharge.
5. Minimum Water Working Pressure Rating: 175 psig.

2.5 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 175-psig minimum.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Standard: UL 199.
2. Pressure Rating: 175 psig.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Standard: UL 1474.
2. Pressure Rating: 250-psig minimum.
3. Body Material: Steel pipe with EPDM-rubber O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

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

2.6 SPRINKLERS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating for Residential Sprinklers: 175-psig maximum.

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. Residential Applications: UL 1626.

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

E. Sprinkler Finishes: Bronze and 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.

1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

G. Sprinkler Guards:

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

2.7 PRESSURE GAUGES

A. Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch diameter.

C. Pressure Gauge Range: 0- to 250-psig minimum.

D. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 SERVICE-ENTRANCE PIPING

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

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping.

C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water service.

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 "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-distribution piping.

C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water supply.

3.3 INSTALLATION OF PIPING

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

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.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

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

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

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

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

J. Install alarm devices in piping systems.

K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 21 05 48 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

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

M. Pressurize and check preaction sprinkler system piping and air-pressure maintenance devices.

N. Fill sprinkler system piping with water.

O. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Section 21 05 33 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 21 07 00 "Fire-Suppression Systems Insulation."

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 21 05 17 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 21 05 18 "Escutcheons for Fire-Suppression Piping."

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. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

J. 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.

K. 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.

L. Extruded-Tee Connections: Form tee in copper tube according to ASTM F2014. 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.

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

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

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.

3.5 INSTALLATION OF VALVES AND SPECIALTIES

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.

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. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.

E. Air Vent:

1. Provide at least one air vent in each wet pipe sprinkler system in accordance with NFPA 13 requirements. Connect vent into top of fire sprinkler piping.
2. Provide dielectric union for dissimilar metals, ball or globe valve, and strainer upstream of automatic air vent.
3. Pipe from outlet of air vent to drain.

3.6 INSTALLATION OF SPRINKLERS

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 IDENTIFICATION

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

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Perform the following 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. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

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

C. Prepare test and inspection reports.

3.9 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.10 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and threaded joints.

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

C. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2 (DN 50) and Smaller, to Be One of the Following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight, black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
4. Standard-weight, galvanized-steel pipe with plain ends; galvanized, plain-end-pipe fittings; and twist-locked joints.
5. Standard-weight, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
6. Standard-weight, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2-1/2 and Larger, to Be One of the Following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
4. Standard-weight, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.11 SPRINKLER SCHEDULE

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

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Residential Sprinklers: Dull chrome.
3. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

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SECTION 21 13 16

DRY-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Specialty valves.
3. Dry-sprinkler system nitrogen generator with purge/vent.
4. Sprinkler piping specialties.
5. Sprinklers.
6. Manual control stations.
7. Pressure gauges.

B. Related Requirements:

1. Section 21 11 19 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
2. Section 21 05 23 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For dry-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittal: For dry-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

D. Qualification Data: For qualified Installer and professional engineer.

E. Design Data: Approved sprinkler piping working plans, prepared according to NFPA 13, including documented approval by authorities having jurisdiction, and including hydraulic calculations if applicable.

F. Field Test Reports:

1. 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."
2. Fire-hydrant flow test report.

G. Field quality-control reports.

H. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
   a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by qualified professional engineer or NICET Level II-certified technician, "Water-Based Systems Layout."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

A. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing nitrogen. Opening of sprinklers releases nitrogen and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

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.

B. Sprinkler system equipment, specialties, accessories, installation, and testing to comply with NFPA 13.

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

1. Maximum protection area per sprinkler according to UL listing.
2. Maximum Protection Area per Sprinkler:

D. Obtain documented approval of sprinkler system design from authorities having jurisdiction.

2.3 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized-Steel Pipe: ASTM A53/A53M, Type E, Pipe ends may be factory or field formed to match joining method.

B. Schedule 10 Galvanized-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

C. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

D. Galvanized-Steel Couplings: ASTM A865/A865M, threaded.

E. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

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

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

H. Plain-End-Pipe Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn or screwed retainer pin to secure pipe in fitting.

I. Grooved-Joint, Steel-Pipe Appurtenances:

1. Pressure Rating: 250-psig minimum.
2. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.4 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Specialty Valves Pressure Rating: 175-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Dry-Pipe Valves:

1. Standard: UL 260.
2. Design: Differential-pressure type.
3. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
4. Air-Pressure Maintenance Device:
   a. Standard: UL 260.
   b. Type: Automatic device to maintain minimum air pressure in piping.
   c. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 300-psig outlet pressure.
5. Nitrogen Generator:
   a. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
   b. Motor Horsepower: Fractional.
      1) Power: 120-V ac, 60 Hz, single phase.

G. Automatic (Ball Drip) Drain Valves:

1. Standard: UL 1726.
2. Pressure Rating: 175-psig minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4.
5. End Connections: Threaded.

2.5 DRY-SPRINKLER SYSTEM NITROGEN GENERATOR WITH PURGE/VENT

A. Acceptable manufacturers: Engineered Corrosion Solutions, General Air Products, Inc., Potter Electric Signal Company, LLC, or approved equal.

B. Description: Nitrogen generator system to serve dry sprinkler zones for piping corrosion mitigation, including system venting. System is to provide required supervisory pressure within sprinkler zone. System is to include either an integrated, oil-less air compressor located within nitrogen generator system package, or a separate vibration-isolation mounted air compressor, also provided by nitrogen generator manufacturer.

C. Standards:

1. FM Approvals 1035.
2. UL 508A listed.

D. Nitrogen Generator:

1. Wall-mounted or skid-mounted nitrogen generator to provide minimum nitrogen purity of 98 percent to the designated sprinkler systems.
2. Power: 120 V ac.
3. Bypass mode and nitrogen generating mode.
4. Minimum Capacity: As recommended by manufacturer.

E. Air Compressor:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Motor Horsepower: Fractional.
   a. Power: 120 V ac, 60 Hz, single phase.
3. Sized for application and capable of achieving system supervisory pressure within 30 minutes in accordance with requirements of NFPA 13. Provide ASME air receiver tank as required to meet requirements on larger systems.
4. Include filters, relief valves, coolers, automatic drains, and gauges.
5. Minimum Capacity: Match capacity of nitrogen generator.

F. Automatic Purge Vent/Valve:

1. Vents oxygen during system nitrogen fill.
2. Automatically closes when 98 percent minimum nitrogen has been reached.
3. Sized to allow correct purge rate per manufacturer's written instructions and with 14 days.
4. Provide one venting device for each dry sprinkler system zone.
5. Include a connection port for a portable nitrogen purity sensor or a nitrogen purity manifold.

G. Supervisory Gas Monitoring - Nitrogen Purity Sensing Device:

1. Permanently Mounted Nitrogen Purity Monitoring Device or Manifold: Permanent monitoring device to continuously monitor system's nitrogen purity.

H. BAS Alarm Integration:

1. Provide nitrogen generation system with integrated leak detection and bypass alarms. Program alarms into controller and connect to BAS.
   a. Leak detection system is to alarm if leaks develop within fire-suppression system piping.

b. Air bypass alarm is to alarm if nitrogen generation system is bypassed by air compressor.

2.6 SPRINKLER PIPING SPECIALTIES

A. General Requirements for Dry-Pipe System Fittings: UL listed for dry-pipe service.

B. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 300 psig.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

C. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 300 psig.
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

D. Branch Line Testers:

1. Standard: UL 199.
2. Pressure Rating: 175-psig minimum.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

E. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 300 psig.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

F. Adjustable Drop Nipples:

1. Standard: UL 1474.
2. Pressure Rating: 250-psig minimum.
3. Body Material: Steel pipe with EPDM O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

2.7 SPRINKLERS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating for Residential Sprinklers: 175-psig maximum.

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Pressure Rating for High-Pressure Automatic Sprinklers: 250-psig minimum.

E. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. Residential Applications: UL 1626.
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

F. Sprinkler Finishes: Bronze.

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

1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

H. Sprinkler Guards:

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

2.8 MANUAL CONTROL STATIONS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve.

B. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.9 PRESSURE GAUGES

A. Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch diameter.

C. Pressure Gauge Range: 0- to 250-psig minimum.

D. Label: Include "WATER" or "AIR/WATER" label on dial face.

E. Air System Piping Gauge: Include "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 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 "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-distribution piping.

C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water supply.

3.2 INSTALLATION OF PIPING

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

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.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

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

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

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

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

I. Install automatic (ball drip) drain valves to drain piping between fire department connections and check valves. Drain to floor drain or to outside building.

J. Connect nitrogen generator to the following piping and wiring:

1. Pressure gauges and controls.
2. Electrical power system.
3. Fire-alarm devices, including low-pressure alarm.

K. Install alarm devices in piping systems.

L. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-

metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.

M. Drain dry-pipe sprinkler piping.

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

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 21 05 17 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 21 05 18 "Escutcheons for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

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

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

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

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

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

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

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

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

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

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

3.4 INSTALLATION OF VALVES AND SPECIALTIES

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.

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. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install dry-pipe and deluge valves with trim sets for nitrogen supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.
   a. Install nitrogen generator and nitrogen-supply piping.
   b. Install air-pressure maintenance device with shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 175-psig maximum inlet pressure.
   c. Install compressed-air-supply piping from building's compressed-air piping system.

3.5 INSTALLATION OF SPRINKLERS

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install sprinklers with water supply from heated space. Do not install pendant or sidewall, sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.6 IDENTIFICATION

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

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Perform the following 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 nitrogen generator.
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.

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

C. Prepare test and inspection reports.

3.8 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.9 PIPING SCHEDULE

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

B. Standard-pressure, dry-pipe sprinkler system, NPS 2 and smaller, to be one of the following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, galvanized-steel pipe with plain ends; plain-end-pipe fittings; and twist-locked joints.
3. Standard-weight, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Standard-pressure, dry-pipe sprinkler system, NPS 2-1/2 and Larger, to be one of the following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 10, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.10 SPRINKLER SCHEDULE

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

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Dry pendent, recessed, and flush sprinklers as indicated.
3. Wall Mounting: Dry sidewall sprinklers.
4. Spaces Subject to Freezing: Upright sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
2. Upright Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 21 13 16

SECTION 22 05 00

COMMON WORK REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. 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.

1.02 REFERENCE

A. Applicable provisions of Division 1 govern this section.

1.03 RELATED REQUIREMENTS

A. Division 1 – General Requirements.

B. Division 31 – Earthwork.

C. Section 07 84 00 – Fire Stopping.

1.04 REFERENCE STANDARDS

A. Abbreviations:

1.	ABMA	American Boiler Manufacturers Association
2.	AGA	American Gas Association
3.	AMCA	Air Movement and Control Association
4.	ANSI	American National Standards Association
5.	ASPE	American Society of Plumbing Engineers
6.	ASME	American Society of Mechanical Engineers
7.	ASSE	American Society of Sanitary Engineering
8.	ASTM	American Society for Testing and Materials
9.	AWWA	American Water Works Association
10.	AWS	American Welding Society
11.	CGA	Compressed Gas Association
12.	EPA	Environmental Protection Agency
13.	GAMA	Gas Appliance Manufacturers Association
14.	IAPMO	International Association of Plumbing & Mechanical Officials
15.	IEEE	Institute of Electrical and Electronics Engineers
16.	ISA	Instrument Society of America
17.	MCA	Mechanical Contractors Association
18.	MICA	Midwest Insulation Contractors Association
19.	MSS	Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc
20.	NBS	National Bureau of Standards
21.	NEBB	National Environmental Balancing Bureau
22.	NEC	National Electric Code
23.	NEMA	National Electrical Manufacturers Association
24.	NFPA	National Fire Protection Association
25.	UL	Underwriters Laboratories Inc.

B. Standards referenced in this section:

1.	ACI 614	Recommended Practice for Measuring, Mixing and Placing of Concrete
2.	ASTM D1557	Standard Test Method for Moisture-Density Relations of Soils
3.	ASTM E814	Standard Test Method for Fire Tests of Through-Penetration Fire Stops
4.	ASTM E84	Standard Test Method for Surface Burning Characteristics of Materials
5.	UL1479	Fire Tests of Through-Penetration Firestops
6.	UL723	Surface Burning Characteristics of Building Materials

1.05 QUALITY ASSURANCE

A. Refer to Division 1, General Conditions, Equals and Substitutions.

B. All products and materials used are to be new, undamaged, clean and in good condition. Existing products and materials are not to be reused unless specifically indicated.

C. 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 for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

1.06 ABBREVIATIONS AND SYMBOLS

A. Key to abbreviations and symbols shall be on the Drawings.

B. The following are additional abbreviations used in the Specifications:

1.	A/E	Architect/Engineer
2.	GC	General Contractor
3.	PC	Plumbing Contractor
4.	FPC	Fire Protection Contractor
5.	HC	Heating Ventilating and Air Conditioning Contractor
6.	EC	Electrical Contractor

1.07 DEFINITIONS

A. Furnish: Supply and deliver to Project site ready for unpacking, assembly, and installation.

B. Install: Operations at Site including unpacking, assembling, erecting, placing, anchoring, applying, finishing, cleaning, and connecting related devices required for product fully functional for intended use after installation.

C. Provide: Furnish and install, such that product is fully functional for intended use.

1.08 COORDINATION

A. The Drawings show the general arrangement of piping and equipment and shall be followed as closely as actual building construction and the work of other trades permits. Architectural and Structural Drawings shall take precedence. Because of the scale of the Drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate conditions affecting the Work and arrange accordingly, providing offsets, fittings and accessories as may be required to meet conditions.

1.09 PROTECTION OF FINISHED SURFACES

A. Refer to Division 1, General Requirements, Protection of Finished Surfaces.

B. Furnish one can of touch-up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

1.10 SLEEVES AND OPENINGS

A. This contractor shall be responsible for all sleeves and openings unless specifically noted on the drawings that openings will be provided by others.

B. Furnish all sleeves required for penetrations. Contractors furnishing sleeves to others for installation shall do this in a timely manner so as not to impede the project schedule.

C. Coordinate location of all sleeves with work of other trades.

D. Provide a layout drawing of all such required sleeves and/or openings to the General Contractor for coordination and the A/E for review and approval. Sleeve and opening sizes and locations shall be dimensioned from column lines and floor elevations.

1.11 SEALING AND FIRESTOPPING

A. Sealing and fire stopping of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

1.12 EQUIPMENT AND MATERIAL SUBMITTALS

A. Refer to Division 1, General Conditions, Submittals.

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 and/or number, as indicated in the contract documents.

C. Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the shop drawing transmittal to the architect/engineer that the equipment submitted and the motor starter schedules are in agreement or indicate any discrepancies. See related comments in Section 22 05 13 in Part 1 under Electrical Coordination.

D. Include wiring diagrams of electrically powered equipment.

E. Submit electronic (PDF) copy of all submittals for review by A/E, Architect, Owner, Owners Representative and Building Operator.

1.13 OFF-SITE STORAGE

A. Any required offsite storage of material is the responsibility of the contractor. Materials or equipment damaged while stored offsite, or while transported to or from offset storage will not be allowed to be installed.

1.14 PERMITS, CERTIFICATES, AND INSPECTIONS

A. Obtain and pay for all required local and State construction permits.

B. Obtain and pay for all required local, State and Federal installation inspections. Include copies of the certificates in the Operating and Maintenance Instructions.

1.15 OPERATION AND MAINTENANCE MANUAL

A. Provide operation and maintenance manuals at the completion of the project and prior to owner training. Operation and Maintenance Manuals shall contain the following information:

1. Table of Contents.
2. Summary sheet that includes Contractor name, Contractors contact information and name of Contractors Project Manager for the project.
3. Warranty letter.
4. Certificates of inspections by regulatory agencies.
5. Record of tests performed to comply with system and contract documents.
6. Copies of all approved submittals.
7. Lubrication instructions, including list and frequency of lubrication.
8. Manufacturer's wiring diagrams for electrically powered equipment.
9. Parts list for manufactured equipment.
10. Valve schedule.
11. Additional items as indicated in technical specification sections.

B. Provide (3) electronic (Adobe PDF) copies of the Operation and Maintenance Manual.

1. Provide each copy on a separate portable USB flash drive.
2. Deliver each portable USB flash drive with hard copy manuals to parties listed above.

1.16 TRAINING OF OWNER PERSONNEL

A. Instruct Owner or Owners facility staff in the proper operation and maintenance of systems and equipment provided as part of this project. The Operation and Maintenance manuals shall be used and referenced during training. Provide multiple training sessions if needed due to project size and seasonal operating constraints.

B. All training times shall be coordinated with the Owner and Owners facility staff a minimum of 2 weeks prior to training.

C. Include not less than 2 hours of training instruction.

D. All training sessions shall be recorded on digital video. The contractor shall provide the recording equipment and equipment operator. Deliver (3) copies of the training video, each to be on separate flash drives to the Owner or Owners facility staff.

1.17 RECORD DRAWINGS

A. Refer to Division 1, General Requirements, Record Drawings.

B. Maintain accurate as-built or record drawings throughout the duration of the project. As-built drawings shall be available on site at all times for review by the A/E, owner or owner's representative.

C. If, during project closeout, the A/E or owner observes installations that are not accurately recorded on the as-built or record drawings, the record drawings will not be accepted and the contractor will be required, at their own expense, to provide updated and accurate record drawings.

D. In addition to the data indicated in the General Requirements, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

1.18 CLEANING

A. Keep the premises broom clean and free of surplus materials, rubbish and debris.

B. After fixtures and equipment have been installed, remove stickers, rust stains, labels, and temporary covers.

C. Foreign matter shall be blown out, or flushed out, of pipes, tanks, pumps, strainers, motors, devices, switches, fixtures, and panels.

D. Boilers and water heaters shall be cleaned, drained, flushed and recleaned until free of oil and debris.

E. Identification plates on equipment shall be free of paint and dirt.

F. Leave the work in a condition ready for operation.

G. Clean all equipment, piping, strainers, filters, etc. prior to building turnover to owner. All systems shall be turned over to owner in condition ready for operation.

1.19 WARRANTY

A. Warrant that work shall function for one year immediately following the acceptance of the system(s). The date of acceptance shall be an agreed upon date by all parties, including Division 22 contractor, General Contractor, Owner, Owners Representative, Tenant and A/E.

B. Keep the system in good working order at no expense, unless defects are clearly the result of improper usage.

C. Warranty calls shall be at no cost to the owner.

D. Submit for acceptance of the work, written certification that the entire system has been installed and adjusted for operation in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 ACCESS PANELS AND DOORS

A. Provide access panels at locations requiring access to mechanical equipment. Locations include, but are not limited to areas above drywall ceilings, shaft enclosures and other furred-in spaces concealing valves, ducts or equipment. Provide UL listed, fire rated access panels when penetrating fire rated chase or shaft areas.

B. Access panels shall be of size required to provide adequate access to equipment. Minimum size shall be 12 inch by 12 inch for hand access and 24 inch by 24 inch for body access.

C. Panels shall be Milcor brand or equivalent.

D. Panels shall include concealed hinges, cam type locking devices, and have frame/border type necessary for particular wall or ceiling construction they are installed. Access panels shall be flush mounted, recessed frame type units. Access panels shall be prime coated steel, able to accept field painting for general applications and stainless steel for use in toilet rooms, shower rooms and similar wet areas.

E. Refer to Architectural Room Finish Schedule for wall and ceiling surfaces and finishes.

F. For non-security applications, panel construction shall utilize 16 gauge frame with not less than 18 gauge hinged door panel. Door locks shall be screwdriver operated for panels in general location applications and shall be key locked for public area applications.

2.02 IDENTIFICATION

A. Stencils

1. Not less than 1 inch high letters/numbers for marking pipe and equipment.

B. Snap-On Pipe Markers

1. Cylindrical self-coiling plastic sheet that snaps over piping insulation and is held tightly in place without the use of adhesive, tape or straps. Not less than 1 inch high letters/numbers and flow direction arrows for piping marking. W. H. Brady, Seton, Marking Services, or equal.

C. Engraved Name Plates

1. White letters on a black background, 1/16 inch thick plastic laminate, beveled edges, screw mounting, Setonply Style 2060 by Seton Name Plate Company or Emedolite- Style EIP by EMED Co., or equal by Marking Services, or W. H. Brady.

D. Valve Tags

1. Round brass tags with 1/2 inch numbers, 1/4 inch system identification abbreviation, 1-1/4 inch minimum diameter, with brass jack chains or brass "S" hooks around the valve stem, available from EMED Co., Seton Name Plate Company, Marking Services, or W. H. Brady.

2.03 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Rated Partitions

1. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with Section 07 84 00 “Fire Stopping”.

2.04 NON-RATED PARTITIONS

A. Pipe Penetrations Thru Below Grade Walls

1. In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated pipe and the cored opening or a water-stop type wall sleeve.

B. Pipe Penetrations

1. At pipe penetrations of non-rated interior walls, floors and exterior walls above grade, use urethane caulk in annular space between pipe insulation and sleeve. For non-rated drywall, plaster or wood walls where sleeve is not required use urethane caulk in annular space between pipe insulation and wall material.

PART 3 - EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Perform all excavation and backfill work to accomplish indicated mechanical systems installation in accordance with Division 31 - Earthwork. Blasting will not be allowed without written permission of the Architect/Engineer.

B. Install lines passing under foundations with minimum of 1-1/2 inch clearance to concrete and insure there is no disturbance of bearing soil.

3.02 CONCRETE WORK

A. All cast-in-place concrete will be performed by the Division 3 Contractor unless otherwise noted. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for support of mechanical equipment.

3.03 CUTTING AND PATCHING

A. Refer to Division 1, General Requirements, Cutting and Patching.

B. Any cutting and patching not specifically indicated to be provided by others shall be performed by the Division 22 contractor.

3.04 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.

3.05 EQUIPMENT ACCESS

A. Install all piping and accessories to permit access to equipment for maintenance and service. 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. Access doors in general construction are to be furnished by the Mechanical Contractor and installed by the General Contractor.

B. Provide color coded thumb tacks or screws, depending on the surface, for use in accessible ceilings which do not require access panels.

3.06 COORDINATION

A. Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, diffusers, register, grilles, and recessed or semi-recessed heating and/or cooling terminal units installed in/on architectural surfaces.

B. Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

3.07 IDENTIFICATION

A. Identify equipment in mechanical equipment rooms by stenciling equipment number and service with one coat of black enamel against a light background or white enamel against a dark background. Use a primer where necessary for proper paint adhesion.

B. Where stenciling is not appropriate for equipment identification, engraved name plates may be used.

C. Identify interior piping not less than once every 30 feet, not less than once in each room, adjacent to each access door or panel, and on both side of the partition where accessible piping passes through walls or floors. Place flow directional arrows at each pipe identification location. Use one coat of black enamel against a light background or white enamel against a dark background.

D. Identify all exterior buried piping for entire length with underground warning tape except for sewer piping which is routed in straight lines between manholes or cleanouts. Place tape 6"-12" below finished grade along entire length of pipe. Extend tape to surface at building entrances, meters, hydrants and valves. Where existing underground warning tape is broken during excavation, replace with new tape identifying appropriate service and securely spliced to ends of existing tape.

E. Identify valves with brass tags bearing a system identification and a valve sequence number. Identify medical gas and vacuum valves with brass tags and wall or cabinet mounted color coded engraved nameplate with the following "(Type of Gas) Shutoff Valve for (Location or Zone)". Valve tags are not required at a terminal device unless the valves are greater than ten feet from the device, located in another room or not visible from device. Provide a typewritten valve schedule and pipe identification schedule indicating the valve number and the equipment or areas supplied by each valve and the symbols used for pipe identification; locate schedules in mechanical room and in each Operating and Maintenance manual. Schedule in mechanical room to be framed under clear plastic.

3.08 LUBRICATION

A. Lubricate all bearings with lubricant as recommended by the manufacturer before the equipment is operated for any reason. Once the equipment has been run, maintain lubrication in accordance with the manufacturer's instructions until the work is accepted by the owner. Maintain a log of all lubricants used and frequency of lubrication; include this information in the Operating and Maintenance Manuals at the completion of the project.

3.09 SLEEVES AND OPENINGS

A. Pipe penetrations in new poured concrete horizontal construction requiring F and T rating: Form opening using hole form or core drill opening. Alternatively provide cast in place fire stopping devices/sleeves.

B. Pipe penetrations in new poured concrete horizontal construction requiring F rating but no T rating: Same as pipe penetrations in new poured concrete construction requiring F and T ratings except that schedule 40 steel sleeves may also be used.

C. Pipe penetrations in new poured concrete horizontal construction that do not require F or T ratings: Provide schedule 40 steel pipe sleeve, form opening using hole form or core drill opening.

D. Where penetrating pipe or conduit weight is supported by floor, provide manufactured product or structural bearing collar designed to carry load.

3.10 SEALING AND FIRE STOPPING

A. Fire and/or Smoke Rated Partitions

1. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

B. Non-Rated Partitions

1. Exterior Wall Openings Below Grade

a. Assemble rubber links of mechanical seal to the proper size for the pipe and tighten in place, in accordance with manufacturer's instructions. Install so that the bolts used to tighten the seal are accessible from the interior of the building or vault.

2. Pipe Penetrations – Interior and Exterior Above Grade

a. Pipe penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the pipe sleeve or cored opening and the pipe or insulation is completely blocked.
b. At interior penetrations, finish should match the adjacent partition finish.

3.11 PENETRATIONS SUBJECT TO WATER INTRUSION

A. For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:

1. Pipe penetration where steel pipe sleeve is used extend steel sleeve 2” above the floor.
2. Pipe penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2” above the floor (provided it meets the device’s UL listing).
3. Pipe penetration where there is no steel sleeve or cast in place fire stopping device/sleeve, provide 2”x 2” x 1/8” galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8” on center. Seal corners watertight with urethane caulk.
4. Floors subject to water intrusion or rooms housing electrical equipment include the following locations:

a. Restrooms.
b. Janitor rooms with sinks.
c. Mechanical and plumbing equipment rooms.
d. Vehicle storage and parking ramps.
e. Data and communication rooms.
f. Electrical equipment rooms.

5. Provide waterproof caulk sealant top coating on fire stopping system (or other approved means to protect the fire stopping system from water) in areas subject to wash down such as Food Service and Dish Washing Areas.

END OF SECTION 22 05 00

SECTION 22 05 13

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

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 MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. 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.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 22 05 13

SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.
4. Silicone sealants.

1.2 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anticorrosion coated or galvanized, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

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

2.2 SLEEVE-SEAL SYSTEMS

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

1. Flexicraft.
2. Trumbell.
3. GPT Industries.
4. Or approved equal.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig minimum.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Stainless steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Description: Nonshrink, 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, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, Use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Using grout or silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:

1. Pipe penetration where steel pipe sleeve is used extend steel sleeve 2” above the floor.
2. Pipe penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2” above the floor (provided it meets the device’s UL listing).
3. Pipe penetration where there is no steel sleeve or cast in place fire stopping device/sleeve, provide 2”x 2” x 1/8” galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8” on center. Seal corners water tight with urethane caulk.
4. Floors subject to water intrusion or rooms housing electrical equipment include the following locations:
   a. Restrooms.
   b. Janitor Rooms w/ Sinks.
   c. Mechanical/Plumbing Equipment Rooms.
   d. Vehicle Storage and Parking Ramps.

e. Data/Telecommunications Rooms.
f. Electrical Equipment Rooms.

E. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

F. Completely seal pipe penetrations, as specified below, for walls of the following rooms below:

1. Non-fire rated mechanical rooms.

G. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 84 13 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.
4. Interior Partitions:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves or PVC pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 22 05 17

SECTION 22 05 18

ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. Manufacturers: BrassCraft Manufacturing Co.; a Masco Company, Dearborn Brass, Keeney Manufacturing Company, ProFlo; a Ferguson Enterprises, Inc. brand.

B. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring clip fasteners.

2.2 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

1. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
   b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
   c. Insulated Piping: One-piece stamped steel polished, chrome-plated finish.
   d. Bare Piping at Wall Penetrations in Finished Spaces: One-piece stamped steel with polished, chrome-plated finish.
   e. Bare Piping at Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

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

1. New Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 22 05 18

SECTION 22 05 19

METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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.

1.3 SUBMITTALS

A. Product Data: For each type of product.

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

C. 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. American, Taylor, Trerice, U.S. Gauge, Weiss, or Winters Instruments. Standard: ASME B40.200.
2. Case: Cast aluminum ; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass.
7. Stem: Aluminum and of length to suit installation.
   a. Design for Thermowell Installation: Bare stem.
8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. 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. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. American, Taylor, Trerice, U.S. Gauge, Weiss, or Winters Instruments. Standard: ASME B40.100.
2. Case: Liquid-filled type(s); cast aluminum or drawn steel ; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. 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.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Brass.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

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 piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, 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 one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install remote-mounted pressure gages on panel.

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

J. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.
2. Inlets and outlets of each domestic water heat exchanger.
3. Inlet and outlet of each domestic hot-water storage tank.
4. Inlet and outlet of each remote domestic water chiller.

K. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

L. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

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

3.2 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be the following:

1. Metal case, industrial-style, liquid-in-glass type.

3.3 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be the following:

1. **Liquid-filled**, **direct** mounted, metal case.

3.4 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: **0 to 160 psi**.

B. Scale Range for Domestic Water Piping: **0 to 100 psi**.

END OF SECTION 22 05 19

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SECTION 22 05 23

VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Stainless steel ball valves.
3. Butterfly valves.
4. Check valves.

1.2 SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Domestic water valves intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an ANSI-accredited third-party certification body) that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
7. ASME B16.34 for flanged and threaded end connections
8. ASME B31.9 for building services piping valves.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

F. Valves in Insulated Piping:

1. Provide 2-inch extended neck stems.

2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:

1. Apollo Valves, Nibco, Milwaukee Valve, or approved equal.
2. Standard: MSS SP-110; MSS SP-145.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Bronze or brass.
9. Ball: Chrome-plated brass.
10. Port: Full.

2.3 STAINLESS STEEL BALL VALVES

A. Stainless Steel Ball Valves, Two Piece with Full Port, Threaded or Flanged Ends:

1. Apollo Valves, Nibco, Milwaukee Valve, or approved equal.
2. Standard: MSS SP-110; MSS SP-145.
3. CWP Rating: 200 psig.
4. Body Design: Split body.
5. Body Material: Type 316 stainless steel.
6. Ends: Threaded or flanged.
7. Seats: PTFE.
8. Stem: Type 316 stainless steel.
9. Ball: Type 316 stainless steel.
10. Port: Full.

2.4 IRON, SINGLE-FLANGE (LUG-TYPE) BUTTERFLY VALVES

A. Iron, Single-Flange (Lug-Type) Butterfly Valves with Aluminum-Bronze Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 250 psig.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM.
6. Stem: One- or two-piece stainless steel.
7. Disc: Aluminum bronze.

B. Iron, Single-Flange (Lug-Type) Butterfly Valves with Ductile-Iron Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 250 psig.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.

4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM.
6. Stem: One- or two-piece stainless steel.
7. Disc: Nickel-plated or -coated ductile iron.

2.5 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. Ductile Iron, Grooved-End Butterfly Valves, 175 CWP:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 175 psig.
3. Body Material: Coated, ductile iron.
4. Stem: Two-piece stainless steel.
5. Disc: Coated, ductile iron.
6. Seal: EPDM.

B. Ductile Iron, Grooved-End Butterfly Valves, 300 CWP:

1. Standard: MSS SP-67, Type I.
2. CWP Rating, NPS 8 and Smaller: 300 psig.
3. CWP Rating, NPS 10 and Larger: 200 psig.
4. Body Material: Coated, ductile iron.
5. Stem: Two-piece stainless steel.
6. Disc: Coated, ductile iron.
7. Seal: [**EPDM**] [**NBR**].

2.6 BRONZE SWING CHECK VALVES

A. Bronze, Swing Check Valves with Bronze Disc, Class 125:

1. Apollo Valves, Nibco, Milwaukee Valve, or approved equal.
2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B62, bronze, lead free.
   e. Ends: Threaded or soldered. See valve schedule articles.
   f. Disc: Bronze.

2.7 IRON, SWING CHECK VALVES

A. Iron, Swing Check Valves with Metal Seats, Class 125:

1. Apollo Valves, Nibco, Milwaukee Valve, or approved equal.
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A126, gray iron with bolted bonnet.
   e. Ends: Flange or threaded. See valve schedule articles.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.

B. Iron, Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:

1. Apollo Valves, Nibco, Milwaukee Valve, or approved equal.
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A126, gray iron with bolted bonnet.
   e. Ends: Flange or threaded. See valve schedule articles.
   f. Trim: Composition.
   g. Seat Ring: Bronze.
   h. Disc Holder: Bronze.
   i. Disc: PTFE.
   j. Gasket: Asbestos free.

C. Iron, Swing Check Valves with Metal Seats, Class 250:

1. Apollo Valves, Nibco, Milwaukee Valve, or approved equal.
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 500 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A126, gray iron with bolted bonnet.
   e. Ends: Flange or threaded. See valve schedule articles.
   f. Trim: Bronze.
   g. 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. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

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

B. Provide support to piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. For valves in horizontal piping, install valves with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags: Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

G. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

H. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, provide the same types of valves with higher CWP ratings.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-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 Stainless Steel Piping, NPS 2 and Smaller: Threaded ends.
8. For Stainless Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze ball valve, one piece with bronze or stainless steel trim. Provide with threaded or solder-joint ends.
2. Bronze ball valves, two piece with full port, and bronze or stainless steel trim. Provide with threaded or solder-joint ends.
3. Stainless steel ball valves with threaded-joint ends.

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

1. Iron, Single-Flange (Lug-Type) Butterfly Valves: 200 CWP, EPDM seat, ductile-iron or stainless steel disc.
2. Ductile-Iron, Grooved-End Butterfly Valves: 175 CWP.

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 SUMMARY

A. Section Includes:

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

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations.

C. Welding certificates.

1.3 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

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

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
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 or stainless steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

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

2.3 TRAPEZE PIPE HANGERS

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

2.4 THERMAL HANGER-SHIELD INSERTS

A. Buckaroos, CADDY, Pipe Shields, Rilco Manufacturing, or equal.

B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

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

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

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

2.5 FASTENER SYSTEMS

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

1. Hilti, ITW/Read Head, or equal.
2. Indoor Applications: Zinc-coated or stainless steel.

3. Outdoor Applications: Stainless steel.

2.6 PIPE-POSITIONING SYSTEMS

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

2.7 EQUIPMENT SUPPORTS

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

2.8 MATERIALS

A. Aluminum: ASTM B 221.

B. Carbon Steel: ASTM A 1011/A 1011M.

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

D. Stainless Steel: ASTM A 240/A 240M.

E. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus [**200 lb**] <**Insert value**>.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

D. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

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

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

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

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

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

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

M. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

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

3.3 EQUIPMENT SUPPORTS

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

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hanger 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.

3.5 ADJUSTING

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

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

3.6 HANGER AND SUPPORT SCHEDULE

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

B. Comply with MSS SP-58 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 finishes.

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

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

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

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

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

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

J. 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. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
4. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
5. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
6. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

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

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

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. C-Clamps (MSS Type 23): For structural shapes.
4. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
5. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
6. 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.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

N. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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

P. 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 33

HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes plumbing piping heat tracing for freeze prevention, domestic hot-water-temperature maintenance, and snow and ice melting on roofs and in gutters and downspouts with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electric heating cable.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Operation and maintenance data.

1.3 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.

C. Electrical Insulating Jacket: Minimum 4.0-mil Kapton with silicone, Tefzel, or polyolefin.

D. Cable Cover: Aluminum braid [**and silicone or Hylar outer jacket**].

E. Maximum Operating Temperature (Power On): [**300 deg F**] <**Insert temperature**>.

F. Maximum Exposure Temperature (Power Off): [**185 deg F**] <**Insert temperature**>.

G. 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.

H. Capacities and Characteristics:

1. Maximum Heat Output: [**6 W/ft.**] [**7.5 W/ft.**] <**Insert value**>.
2. Piping Diameter: <**Insert** NPS>.
3. Number of Parallel Cables: <**Insert number**>.
4. Spiral Wrap Pitch: <**Insert** inches>.
5. Electrical Characteristics for Single-Circuit Connection:
   a. Volts: [**120**] [**208**] [**240**] [**277**] [**480**] <**Insert value**>.
   b. Phase: <**Insert value**>.
   c. Hertz: <**Insert value**>.
   d. Full-Load Amperes: <**Insert value**>.
   e. Minimum Circuit Ampacity: <**Insert value**>.
   f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Pair of parallel [**No. 16**] [**No. 18**] AWG, [**tinned**] [**nickel-coated**], stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: [**Tinned-copper**] [**Stainless-steel**] braid [**and polyolefin outer jacket with ultraviolet inhibitor**].

E. Maximum Operating Temperature (Power On): [**150 deg F**] <**Insert temperature**>.

F. Maximum Exposure Temperature (Power Off): [**185 deg F**] <**Insert temperature**>.

G. 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.

H. Capacities and Characteristics:

1. Maximum Heat Output: [**3 W/ft.**] [**5 W/ft.**] [**8 W/ft.**] [**10 W/ft.**] [**12 W/ft.**] <**Insert value**>.
2. Piping Diameter: <**Insert** NPS>.
3. Number of Parallel Cables: <**Insert number**>.
4. Spiral Wrap Pitch: <**Insert** inches>.
5. Electrical Characteristics for Single-Circuit Connection:
   a. Volts: [**120**] [**208**] [**240**] [**277**] [**480**] <**Insert value**>.
   b. Phase: <**Insert value**>.
   c. Hertz: <**Insert value**>.
   d. Full-Load Amperes: <**Insert value**>.
   e. Minimum Circuit Ampacity: <**Insert value**>.
   f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.3 CONTROLS

A. Pipe-Mounted Thermostats for Freeze Protection:

1. Remote bulb unit with adjustable temperature range from [**30 to 50 deg F**] <**Insert temperature range**>.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 22 05 53 "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:

1. Snow and Ice Melting on Roofs and in Gutters and Downspouts: [**Plastic-insulated, series-resistance**] [**Self-regulating, parallel-resistance**] heating cable.
2. Temperature Maintenance for Domestic Hot Water: Self-regulating, parallel-resistance heating cable.

3.2 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

B. Electric Heating-Cable Installation for Snow and Ice Melting on Roofs and in Gutters and Downspouts: Install on roof and in gutters and downspouts with clips furnished by manufacturer that are compatible with roof, gutters, and downspouts.

C. Electric Heating-Cable Installation for Freeze Protection for Piping:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Section 22 07 19 "Plumbing Piping Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

D. Electric Heating-Cable Installation for Temperature Maintenance for Domestic Hot Water:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install insulation over piping with electric heating cables according to Section 22 07 19 "Plumbing Piping Insulation."
3. Install warning tape on piping insulation where piping is equipped with electric heating cables.

E. Set field-adjustable switches and circuit-breaker trip ranges.

F. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

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

D. Prepare test and inspection reports.

E. Remove and replace damaged heat-tracing cables.

END OF SECTION 22 05 33

SECTION 22 05 93

TESTING, ADJUSTING, AND BALANCING FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. TAB of domestic water system.
2. TAB of plumbing equipment:
   a. Domestic hot-water in-line circulation pumps.
3. Pipe-leakage test verification.

1.2 DEFINITIONS

A. NEBB: National Environmental Balancing Bureau.

B. TAB: Testing, adjusting, and balancing.

C. TABB: Testing, Adjusting, and Balancing Bureau.

D. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

E. TDH: Total dynamic head.

1.3 QUALITY ASSURANCE

A. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

B. ASHRAE 111 Compliance: Requirements in ASHRAE 111 applicable to analogous domestic water system and plumbing equipment balancing.

C. ASHRAE 188 Compliance: Comply with balancing and report requirements, Section 8.3 "Balancing."

D. Code and Authorities Having Jurisdiction Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, and balancing valves and fittings. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine approved submittals for plumbing systems and equipment.

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

E. Examine equipment performance data, including pump curves.

1. Relate performance data to Project conditions and requirements, including pump system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate pump system-effect factors to reduce performance ratings of plumbing equipment when installed under conditions different from the conditions used to rate equipment performance. 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 plumbing equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

J. Examine system pumps to ensure absence of entrained air in the suction piping.

K. Examine operating safety interlocks and controls on plumbing equipment.

L. 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. Perform system-readiness checks of plumbing systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Domestic Water System:
   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed in accordance with applicable code and authority having jurisdiction.
   b. Water heaters are installed and functioning.
   c. Piping is complete and all points of outlet are installed.
   d. Water treatment is complete.
   e. Systems are flushed, filled, and air purged.
   f. Strainers are clean.
   g. Control valves are functioning in accordance with the sequence of operation.
   h. Shutoff and balance valves are 100 percent open.
   i. Hot-water circulating pumps are operational and proper rotation is verified.
   j. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 and in this Section.

B. Cut insulation, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. Where holes for probes are required in piping or equipment, install pressure and temperature test plugs to seal systems.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 22 07 19 "Plumbing Piping Insulation."

C. Mark equipment and balancing devices, including valve position indicators 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 PLUMBING EQUIPMENT

A. Test, adjust, and balance plumbing equipment indicated on Drawings, including, but not limited to, the following:

1. Domestic water in-line pumps.
2. Domestic water heaters.

3.5 PROCEDURES FOR DOMESTIC WATER SYSTEMS

A. Prepare test reports for pumps and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required equipment flow rates with system design flow rates.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare domestic water systems for testing and balancing as follows:

1. Check expansion tank for proper setting.
2. Check water heater for proper discharge temperature setting.
3. Check remotest point of outlet for adequate pressure.
4. Check flow-control valves for proper position.
5. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
6. Verify that motor controllers are equipped with properly sized thermal protection.
7. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

G. Check settings and operation of each safety valve. Record settings.

3.6 PROCEDURES FOR DOMESTIC HOT-WATER CIRCULATING INLINE PUMP

A. Balance system with manual or automatic balancing valves by setting at design flow.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

B. Adjust pump to deliver total design flow.

1. Measure pump TDH as follows:
   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
   b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
   c. Convert pressure to head and correct for differences in gauge heights.
   d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
3. Mark final settings and verify that all memory stops have been set.
4. Verify final system conditions as follows:
   a. Re-measure and confirm that total flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
   c. Mark final settings.

3.7 PROCEDURES FOR WATER HEATERS

A. Electric Water Heaters:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Measure and record pressure drop.
4. Record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h of heating output.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.

END OF SECTION 22 05 93

SECTION 22 07 19

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Sanitary waste piping exposed to freezing conditions.
5. Storm-water piping exposed to freezing conditions.
6. Roof drains and rainwater leaders.
7. Supplies and drains for handicap-accessible lavatories and sinks.

1.2 SUBMITTALS

A. Product Data: For each type of product.

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 attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

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

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

1.4 COORDINATION

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

C. Coordinate installation and testing of heat tracing.

1.5 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground 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 into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.

1. Armstrong, Childers, Dow, Halstead, Johns-Mansville, or approved equal.
2. Preformed Pipe Insulation: Type I, Grade A factory-applied ASJ-SSL.
3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

1. Armstrong, Childers, Dow, Halstead, Johns-Mansville, or approved equal.

C. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Armstrong, Childers, Dow, Halstead, Johns-Mansville, or approved equal.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Armstrong, Childers, Dow, Halstead, Johns-Mansville, or approved equal.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.5 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.
3. Color: White or gray.

C. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Fire- and water-resistant, flexible, elastomeric sealant.
2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. 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-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. 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.

2.8 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

2.9 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Brocar, EBC, McGuire, Plumberex, or Truebro.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 PREPARATION

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

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.2 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 of 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, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) 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 storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the contract documents, unless otherwise approved by the engineer-of-record.

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 attached to structure with vapor-barrier mastic.
3. Install insert materials and 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, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, in accordance with 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.

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 in similar fashion to butt joints.

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

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

3.3 PENETRATIONS

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

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

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

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

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

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

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

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.4 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 below.

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

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered or routed fittings made from same material and density as that of 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 that 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 that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 2 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, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

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 that of adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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.

3.5 INSTALLATION OF GLASS-FIBER

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 jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with 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 prefabricated 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 glass-fiber or mineral-wool 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 prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated 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 prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated 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.

3.6 INSTALLATION OF FIELD-APPLIED JACKETS

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

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

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch 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.

C. 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.

D. 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 o.c. and at end joints.

3.7 PIPING INSULATION SCHEDULE, GENERAL

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

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

1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.8 INDOOR PIPING INSULATION SCHEDULE

A. Provide insulation on new piping as indicated in the following schedule. Provide jacketing as schedule unless specified otherwise herein.

SERVICE	INSULATION	JACKET	INSULATION THICKNESS BY PIPE SIZE			
			< 1”	1-1/4” to 2”	2-1/2” to 4”	5” and Larger
Domestic Cold Water	Glass Fiber	ASJ-SSL	0.5”	0.5”	1”	1”
Domestic Hot Water	Glass Fiber	ASJ-SSL	1”	1”	1.5”	1.5”
Domestic Hot Water	Glass Fiber	ASJ-SSL	1”	1”	1.5”	1.5”

Recirculation						
Non-Potable Cold Water	Glass Fiber	ASJ-SSL	0.5”	0.5”	1”	1”
Tempered Water	Glass Fiber	ASJ-SSL	0.5”	0.5”	1”	1”
Storm Drain / Overflow Storm Drain *	Glass Fiber	ASJ-SSL	---	---	1”	1”
Clearwater Waste *	Glass Fiber	ASJ-SSL	---	1”	1”	1”

* Provide pipe insulation on above ground horizontal storm and clearwater drain piping, underside of roof drain, and initial 5 feet of vertical conductors.

END OF SECTION 22 07 19

SECTION 22 11 16

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Ductile-iron pipe and fittings.
3. Piping joining materials.
4. Transition fittings.
5. Dielectric fittings.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. System purging and disinfecting activities report.

C. Field quality-control reports.

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, NSF 61, and NSF 372.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type L.

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

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

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

E. Cast Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

F. Wrought Copper Unions: ASME B16.22.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

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 B32, lead-free alloys.

D. Flux: ASTM B813, water flushable.

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

2.5 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.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Standard: ASSE 1079.
2. Pressure Rating: 175 psig minimum at 180 deg F.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Standard: ASSE 1079.
2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 175 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Nonconducting materials for field assembly of companion flanges.
2. Pressure Rating: 175 psig.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

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

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

C. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 12 and larger Insert pipe size range, shall be the following:

1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

D. Aboveground domestic water piping, shall be the following:

1. Hard copper tube, ASTM B88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.

E. Aboveground, combined domestic water-service and fire-service-main piping, NPS 6 to NPS 12, shall be the following:

1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

3.2 EARTHWORK

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

3.3 INSTALLATION OF PIPING

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

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install valves according to the following:

1. Section 22 05 23 "Valves for Plumbing Piping."

E. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 11 19 "Domestic Water Piping Specialties."

F. Install domestic water piping level and plumb.

G. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

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

I. 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.

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

K. Install piping to permit valve servicing.

L. 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.

M. Install piping free of sags and bends.

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

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

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

Q. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 11 23.21 "Inline, Domestic-Water Pumps."

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

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

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 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 B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

E. 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.

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

3.5 INSTALLATION OF TRANSITION FITTINGS

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.6 INSTALLATION OF DIELECTRIC FITTINGS

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

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

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

3.7 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

B. Install hangers for copper and ductile iron tubing and piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of copper and ductile iron tubing and piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.8 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.

3.9 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 00 "Common Work Requirements for Plumbing."

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 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 at the request of the engineer.

3.12 CLEANING

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

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
   e. Submit water samples in sterile bottles to authorities having jurisdiction.

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

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

END OF SECTION 22 11 16

SECTION 22 11 19

DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Balancing valves.
4. Temperature-actuated, water mixing valves.
5. Strainers for domestic water piping.
6. Hose bibbs.
7. Wall hydrants.
8. Drain valves.
9. Water-hammer arresters.

B. Related Requirements:

1. Section 22 05 19 "Meters and Gauges for Plumbing Piping" for thermometers, pressure gauges, and flow meters in domestic water piping.
2. Section 22 11 16 "Domestic Water Piping" for water meters.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PERFORMANCE REQUIREMENTS

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

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers: Apollo Valves, Watts, Zurn, or approved equal.
2. Standard: ASSE 1001.
3. Body: Bronze.

4. Inlet and Outlet Connections: Threaded.
5. Refer to schedule on drawings.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Apollo Valves, Watts, Zurn, or approved equal.
2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Refer to schedule on drawings.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Apollo Valves, Watts, Zurn, or approved equal.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Body: Bronze or stainless steel.
5. Pressure Loss: 12 psig maximum, through middle third of flow range.
6. Refer to schedule on drawings.

2.5 BALANCING VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Bell & Gossett Circuit Setter Plus, or approved equal.
2. Body: Bronze, lead free, ball, or plug type with calibrated orifice or venturi.
3. Ball: Stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 200 psig.
10. Maximum Operating Temperature: 250 deg F.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Manufacturers: Apollo Valves, Watts, Zurn, or approved equal.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated for NPS 2-1/2 and larger.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Screen: Stainless steel with round perforations unless otherwise indicated.
6. Drain: Pipe plug or factory-installed, hose-end drain valve.

2.7 HOSE BIBBS

A. Hose Bibbs:

1. Manufacturers: Watts, Woodford, Zurn, or approved equal.
2. Standard: ASME A112.18.1 for sediment faucets.

3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Refer to schedules on drawings.

2.8 WALL HYDRANTS

A. Nonfreeze Vacuum Breaker Wall Hydrants:

1. Watts, Woodford, Zurn, or approved equal.
2. Standard: ASSE 1019, Type B.
3. Type: 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.
10. Refer to schedule on drawings.

2.9 DRAIN VALVES

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

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

2.10 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters WHA:

1. Manufacturers: MIFAB, PPP, Sioux Chief, Watts, Zurn
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

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

B. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.

C. Y-Pattern Strainers: For water, install on supply side of system protecting.

D. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

3.2 PIPING CONNECTIONS

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

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

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

A. Connect control wiring in accordance with Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.5 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Backflow preventers.

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 00 "Common Work Requirements for Plumbing."

3.6 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

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

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

D. Adjust each reduced-pressure-principle backflow preventer in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections.

1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.
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 unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

C. Prepare test and inspection reports.

END OF SECTION 22 11 19

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SECTION 22 11 23.21

INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Horizontally mounted, in-line, close-coupled centrifugal pumps.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 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.

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

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

2.2 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.

B. Armstrong, Bell & Gossett, Grundfos, or Taco.

C. Capacities and Characteristics:

1. Refer to schedules on drawings.

D. Motor: Single speed, with grease-lubricated ball bearings; rigidly mounted to pump casing.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 05 13 "Common Motor Requirements for Plumbing 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.

2.4 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. Enclosure: NEMA 250.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: 24 V ac.
7. Settings: Start pump at 110 deg F and stop pump at 120 deg F.

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Enclosure: NEMA 250, suitable for wall mounting.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: 24 V ac.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with HI 1.4.

B. Mount pumps in orientation complying with manufacturer's written instructions.

C. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.

1. Comply with requirements for hangers and supports specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

D. Install thermostats in hot-water return piping.

E. Install timers adjacent to pump.

F. Identify system components. Comply with requirements for identification specified in Section 22 05 00 "Common Work Requirements for Plumbing" for identification of pumps.

G. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats and timers 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.

3.2 PIPING CONNECTIONS

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

B. Where installing piping adjacent to inline, domestic-water pumps, allow space for 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 flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
   a. Horizontally mounted, in-line, close-coupled centrifugal pumps.
   b. Comply with requirements for flexible connectors specified in Section 22 11 16 "Domestic Water Piping."

D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 22 11 19 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:

1. Section 22 05 23 "Valves for Plumbing Piping."
2. Install pressure gauge and snubber at suction of each pump and pressure gauge and snubber at discharge of each pump. Install at integral pressure-gauge tappings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between temperature controllers and devices.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

C. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust inline, 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.

END OF SECTION 22 11 23.21

SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hubless cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe fittings.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1.3 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 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.

2.2 PIPING MATERIALS

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

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

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. AB&I, Charlotte Pipe, or Tyler Pipe.

B. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A 888 or CISPI 301.

C. CISPI, Hubless-Piping Couplings:

1. Couplings shall bear CISPI collective trademark.
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.

2.4 PVC PIPE AND FITTINGS

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

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

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

D. Adhesive Primer: ASTM F 656.

E. Solvent Cement: ASTM D 2564.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Nonpressure Transition Couplings:
    a. Standard: ASTM C 1173.
    b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. End Connections: Same size as and compatible with pipes to be joined.
    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.
3. Shielded, Nonpressure Transition Couplings:
    a. Anaco, Proflex, MIFAB, PipeConx
    b. Standard: ASTM C 1460.
    c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
    d. End Connections: Same size as and compatible with pipes to be joined.

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.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.

2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. 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.
2. 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.
   a. Straight tees, elbows, and crosses may be used on vent lines.
3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
   a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

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

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

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

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

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

P. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping.
   a. Comply with requirements for backwater valves specified in Section 22 13 19 "Sanitary Waste Piping Specialties."
2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
   a. Comply with requirements for cleanouts specified in Section 22 13 19 "Sanitary Waste Piping Specialties."
3. Install drains in sanitary waste gravity-flow piping.
   a. Comply with requirements for drains specified in Section 22 13 19 "Sanitary Waste Piping Specialties."

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

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

1. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

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

1. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

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

1. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

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. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

C. Plastic, Nonpressure-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 ODs.
2. In Waste Drainage Piping: **Shielded**, nonpressure transition couplings.

3.5 VALVE INSTALLATION

A. Comply with requirements in Section 22 05 23 "Valves for Plumbing Piping," for general-duty valve installation requirements.

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.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

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

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for cast-iron soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Install hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

E. Support vertical runs of cast iron soil piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

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 waste and vent piping to the following:

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

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

E. 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.

B. Comply with requirements for identification specified in Section 22 05 00 "Common Work Requirements 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 waste 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.
   a. 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 waste and vent piping until it has been tested and approved.
   a. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
   a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
   b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
   c. 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.
   a. 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.
   b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
   c. Air pressure must remain constant without introducing additional air throughout period of inspection.
   d. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

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

B. Protect sanitary waste and vent piping 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 PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

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

B. Soil waste and vent piping shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 22 13 16

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SECTION 22 13 19

SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cleanouts.
2. Floor drains.
3. Miscellaneous sanitary drainage piping specialties.

B. Related Requirements:

1. Section 07 72 00 "Roof Accessories" for preformed flashings.
2. Section 07 84 13 "Penetration Firestopping" for through-penetration firestop assemblies.
3. Section 22 14 23 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

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

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.2 CLEANOUTS

A. Cast Iron Floor Cleanouts:

1. J.R.Smith, Josam, MIFAB, Sioux Chief, Wade, Watts, or Zurn.
2. See schedule on drawings.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. J.R.Smith, Josam, MIFAB, Sioux Chief, Wade, Watts, or Zurn.
2. Standard: ASME A112.6.3.
3. See schedule on drawings.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

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

B. Floor-Drain, Inline Trap Seal:

1. Acceptable manufacturers: ProSet, or equal.
2. Description: Inline floor drain trap seal, forming a physical barrier to slow trap evaporation while not impeding flow from drain.
3. Material: Polymer.
4. Standard: Tested and certified in accordance with ASSE 1072.
5. Listing: ICC-ES listed.
6. Size: Same as floor drain outlet or strainer throat.

C. Air-Gap Fittings:

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

D. Sleeve Flashing Device:

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

E. Stack Flashing Fittings:

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.

3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

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

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

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

E. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

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

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

H. Install wood-blocking reinforcement for wall-mounting-type specialties.

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

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

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

K. Install trench drains at low points of surface areas to be drained.

1. Set grates of drains flush with finished surface, unless otherwise indicated.
2. Install on support devices, so that top will be flush with adjacent surface.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 22 13 16 "Sanitary Waste 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 LABELING AND IDENTIFYING

A. 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.

1. Nameplates and signs are specified in Section 22 05 00 "Common Work Requirements for Plumbing."

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 14 13

FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hubless, cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe and fittings.

1.2 SUBMITTALS

A. Product Data: For each type of product.

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

1. Storm Drainage Piping: 10-foot head of water.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. AB&I, Charlotte Pipe, or Tyler Pipe

B. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A 888 or CISPI 301.

C. CISPI, Hubless-Piping Couplings:

1. Couplings shall bear CISPI collective trademark.
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.
4. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Hubless-Piping Couplings:

1. Standard: ASTM C 1277.

2. Description: Two-piece ASTM A 48A/48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

A. Charlotte Pipe, Cresline, Nibco, or Spears

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

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

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

E. Adhesive Primer: ASTM F 656.

F. Solvent Cement: ASTM D 2564.

2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs 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. Shielded, Nonpressure Transition Couplings:
   Anaco, Proflex, MIFAB, PipeConx
   a. Standard: ASTM C 1460.
   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.

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.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.

2. Install piping as indicated unless deviations from layout are approved on coordination drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.

1. Do not change direction of flow more than 90 degrees.
2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
   a. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

L. Install piping at the following minimum slopes unless otherwise indicated:

1. Horizontal and Building Storm Drain: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.

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

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

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

P. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.
   a. Comply with requirements for cleanouts specified in Section 22 14 23 "Storm Drainage Piping Specialties."
2. Install drains in storm drainage gravity-flow piping.
   a. Comply with requirements for drains specified in Section 22 14 23 "Storm Drainage Piping Specialties."

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

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

1. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

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

1. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

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

1. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hubless, Cast-Iron Soil Piping Coupled Joints:

1. Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. PVC, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendices.

C. Joint Restraints and Sway Bracing:

1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:
   a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
   b. Provide rigid sway bracing for pipe and fittings 4 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.
   c. Provide rigid sway bracing for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction and branch openings.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Drainage Piping: Shielded, nonpressure transition couplings.

3.5 VALVE INSTALLATION

A. General valve installation requirements for general-duty valve installations are specified in the following Sections:

1. Section 22 05 23 "Valves for Plumbing Piping."

B. Shutoff Valves:

1. Install full port ball shutoff valve on each sump pump discharge.

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

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

1. Install backwater valves in accessible locations.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for cast-iron soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Install hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

E. Support vertical cast-iron soil piping with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent, but as a minimum at base and at each floor.

F. Support vertical PVC piping with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Comply with requirements for cleanouts and drains specified in Section 22 14 23 "Storm Drainage Piping Specialties."

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

E. 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 storm drainage piping.

B. Comply with requirements for identification specified in Section 22 05 00 "Common Work Requirements 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.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.
   a. Expose work that was covered or concealed before it was tested.
3. Test Procedure:
   a. Test storm drainage piping on completion of roughing-in.
   b. 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 until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

C. Piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

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.

3.11 PIPING SCHEDULE

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

B. Storm drainage piping shall be the following:

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

END OF SECTION 22 14 13

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SECTION 22 14 23

STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Miscellaneous storm drainage piping specialties.
2. Cleanouts.

B. Related Requirements:

1. Section 07 62 00 "Sheet Metal Flashing and Trim" for penetrations of roofs.
2. Section 07 84 13 "Penetration Firestopping" for firestopping roof penetrations.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected branch.
3. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk or raised-head, brass plug.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected branch.
3. Type: Cast-iron soil pipe with cast-iron ferrule, heavy-duty, adjustable housing.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Not required.
6. Outlet Connection: No hub.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with setscrews or other device.
9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Extra-Heavy Duty.
12. Riser: ASTM A74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: No-hub, cast-iron soil pipe test tee as required to match connected piping.
4. Closure Plug:
   a. Brass.
   b. Countersunk or raised head.
   c. Drilled and threaded for cover attachment screw.
   d. Size: Same as, or not more than, one size smaller than cleanout size.
5. Wall Access, Cover Plate: Round, chrome-plated brass or stainless steel cover plate with screw.
6. Wall Access, Frame and Cover: Round, nickel-bronze, copper-alloy, or stainless steel wall-installation frame and cover.

D. Test Tees:

1. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure Plug: Countersunk or raised head, brass.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas in accordance with 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 cleanouts in aboveground piping and building drain piping in accordance with the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 6. Use NPS 6 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals per code.
4. Locate cleanouts at base of each vertical storm piping conductor.

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

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

E. Install test tees in vertical conductors and near floor.

F. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

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

H. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping".

I. Comply with requirements for piping specified in Section 22 14 13 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.2 INSTALLATION OF FLASHING

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

3.3 PROTECTION

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

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

END OF SECTION 22 14 23

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SECTION 22 14 29

SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sump pumps.
2. Sump-pump basins and basin covers.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

C. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 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.

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

2.2 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal and Double-Seal Sump Pumps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bell & Gossett; a Xylem brand.
   b. Goulds Water Technology; a Xylem brand.
   c. Weil Pump; a Wilo Company.
   d. Zoeller Company.
2. Description: Factory-assembled and tested sump-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced, cast iron design for clear wastewater handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.

7. Seal: Mechanical.
8. 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.
   a. Motor Housing Fluid: Air.
9. Controls:
   a. Enclosure: NEMA Type 4X.
   b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
   c. Automatic Alternator (Duplex Units): Start pumps on successive cycles and start multiple pumps if one cannot handle load.
   d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
   e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
10. Control-Interface Features:
   a. Remote Alarm Contacts: For remote alarm interface.
   b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
      1) Alarm status.

2.3 SUMP-PUMP CAPACITIES AND CHARACTERISTICS

A. Refer to equipment schedule on drawings.

2.4 SUMP-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, perforated in elevator shafts, 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.
2. Manhole Required in Cover: Yes, for duplex.

2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 05 13 "Common Motor Requirements for Plumbing 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.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 14 13 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection.
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 if requested by the engineer.

END OF SECTION 22 14 29

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SECTION 22 33 00

ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial, light-duty, storage, electric, domestic-water heaters.
2. Domestic-water heater accessories.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

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

C. Product Certificates: For each type of commercial, electric, domestic-water heater.

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

E. Sample warranty.

F. Operation and maintenance data.

1.3 COORDINATION

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

1.4 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.
   a. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
      1) Storage Tank: Three years.
      2) Controls and Other Components: 1 year.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

C. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:

1. A.O. Smith, Bradford White, Rheem, or Equal.
2. Standard: UL 174.
3. Storage-Tank Construction: Steel, vertical arrangement.
    a. Tappings: ASME B1.20.1 pipe thread.
    b. Pressure Rating: 150 psig.
    c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
4. Factory-Installed, Storage-Tank Appurtenances:
    a. Anode Rod: Replaceable magnesium.
    b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
    c. Drain Valve: Corrosion-resistant metal with hose-end connection.
    d. Insulation: Comply with ASHRAE/IES 90.1.
    e. Jacket: Steel with enameled finish or high-impact composite material.
    f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
    g. Heating Elements: Electric, screw-in immersion type.
    h. Temperature Control: Adjustable thermostat.
    i. Safety Control: High-temperature-limit cutoff device or system.
    j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

B. Capacity and Characteristics:

1. Refer to equipment schedule on drawings.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.

B. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.

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

D. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.

E. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

F. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

G. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting:

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use 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. Anchor domestic-water heaters to substrate.

B. Install electric, domestic-water heaters level and plumb, in accordance with 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 "Valves for Plumbing Piping."

C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-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.

1. In finished toilet rooms, provide drain line in wall and penetrate wall directed toward middle of room with floor drain. Provide escutcheon on wall penetration.

D. 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 electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 22 11 19 "Domestic Water Piping Specialties."

E. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

F. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 22 05 23 "Valves for Plumbing Piping," and comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

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

H. Fill electric, domestic-water heaters with water.

I. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

J. Identify system components. Comply with requirements for identification specified in Section 22 05 00 "Common work Requirements for Plumbing."

3.2 PIPING CONNECTIONS

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

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

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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 operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain commercial, electric, domestic-water heaters. Training shall be a minimum of two hour(s).

END OF SECTION 22 33 00

SECTION 22 42 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Drinking Fountains.
2. Water closets.
3. Lavatories.
4. Lavatory faucets
5. Service sinks.
6. Supply fittings.
7. Waste fittings.
8. Grout.

1.02 SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Lavatory faucets.
2. Water Closet flush valves.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Standards:

1. ASME A112.19.1/CSA B45.2 - Enamelled Cast Iron and Enamelled Steel Plumbing Fixtures.
2. IAPMO Z124/CSA B45.5 – Plastic Plumbing Fixtures.
3. ASME A112.19.5/CSA B45.15 - Flush Valves and Spuds For Water Closets, Urinals, and Tanks.
4. ASSE 1037/ASME A112.1037/CSA B125.37 - Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures.
5. IAMPO/ANSI Z124.5 – Plastic Toilet Seats.
6. ASME A112.6.1M – Floor Affixed Supports for Off-The-Floor Plumbing Fixtures for Public Use.
7. ICC A117.1 – Accessible and Usable Buildings and Facilities.
8. ASTM A1045 - Flexible PVC Gaskets Used In Connection of Vitreous China Plumbing Fixtures To Sanitary Drainage Systems.
9. ASME A112.4.3 - Plastic Fittings for Connecting Water Closets to the Sanitary Drainage System.
10. ASME A112.18.2/CSA B125.2 – Plumbing Waste Fittings.
11. ASME A112.18.1/CSA B125.1 - Plumbing Supply Fittings.

2.02 DRINKING FOUNTAINS

A. Refer to schedules on drawings for fixture information not listed in specification.

1. Manufacturers: Acorn Aqua, Elkay, Filtrine, Halsey, Taylor, Haws, Oasis, or Sunroc.

2.03 WATER CLOSETS

A. Refer to schedules on drawings for fixture information not listed in specification.

1. Manufacturers: American Standard, Kohler, Toto, or Zurn.

B. Water Closet Flushometer Valves:

1. Manufacturers: Sloan (Royal Series), Toto, or Zurn (Aquavantage Series).

C. Toilet Seats:

1. Manufacturers: Bemis, Benneke, Church, Olsonite, Kohler, or Zurn.

D. Water-Closet Carrier:

1. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space where applicable.

2.04 LAVATORIES

A. Refer to schedules on drawings for fixture information not listed in specification.

2.05 LAVATORY FAUCETS

A. Refer to schedules on drawings for fixture information not listed in specification.

1. Manufacturers: Bradley, Chicago Faucet, Kohler, Sloan, Speakman, or Zurn.

B. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.

2.06 SERVICE SINKS

A. Refer to schedules on drawings for fixture information not listed in specification.

B. Service Sinks - Molded Stone, Floor Mounted:

1. Fixture:
   a. Standard: ASME A112.18.2/CSA B125.2.
   b. Rim Guard: On all top surfaces.
   c. Drain: Grid with NPS 3 outlet.
2. Mounting: On floor and flush to wall.

2.07 MANUALLY OPERATED FAUCETS

A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.

B. Refer to schedules on drawings for fixture information not listed in specification.

C. Commercial Service Sink Faucets - Manual Type:

1. Description: Wall/back mounted, brass body, with integral service stops, checks, spout with bucket/pail hook, 3/4-inch hose thread end, integral vacuum breaker, inlets 8 inches o.c., and two-handle mixing.
2. Faucet:
   a. Standards:
      1) ASME A112.18.1/CSA B125.1.
      2) ICC A117.1.
      3) ASSE 1001 (VB).
      4) Vacuum Breaker: Required for hose outlet.

2.08 SUPPLY FITTINGS

A. Refer to schedules on drawings for fixture information not listed in specification.

B. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.

C. Standard: ASME A112.18.1/CSA B125.1.

D. Lavatory Supply Fittings:

1. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
2. Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.
   a. Operation: Loose key.
3. Risers:
   a. Size:
      1) NPS 3/8 for lavatories.
   b. Material: Chrome-plated, soft-copper flexible tube riser.

2.09 WASTE FITTINGS

A. Refer to schedules on drawings for fixture information not listed in specification.

B. Standard: ASME A112.18.2/CSA B125.2.

C. Drain: Grid type with NPS 1-1/4 offset tailpiece for accessible lavatories.

D. Drain: Pop-up type with NPS 1-1/4 straight tailpiece as part of faucet for standard lavatories.

E. Trap:

1. Size:
   a. NPS 1-1/2 by NPS 1-1/4 for lavatories.
2. Material:

a. Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated-brass or -steel wall flange.

2.10 GROUT

A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000 psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install plumbing fixtures level and plumb in accordance with roughing-in drawings.

B. Water Closets

1. Examination:
   a. Examine roughing-in for water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.
   b. Examine walls and floors for suitable conditions where water closets will be installed.
   c. Proceed with installation only after unsatisfactory conditions have been corrected.
2. Installation, General:
   a. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
   b. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.

3. Support Installation:
   a. Install supports, affixed to building substrate, for floor-mounted water closets.
   b. Use carrier supports with waste-fitting assembly and seal.
   c. Install floor-mounted water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
   d. Install wall-mounted water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
   e. Measure support height installation from finished floor, not structural floor
4. Flushometer-Valve Installation:

5. Install toilet seats on water closets.

C. 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. Use ball valves if supply stops are not specified with fixture. Comply with valve requirements specified in Section 22 05 23 "Valves for Plumbing Piping".

D. 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.

E. Install traps on fixture outlets.

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

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

H. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."

3.02 PIPING CONNECTIONS

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

B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

D. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

E. Where installing piping adjacent to plumbing fixtures, allow space for service and maintenance.

3.03 ADJUSTING

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

B. Adjust water pressure at faucet and flushometers to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.04 CLEANING AND PROTECTION

A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.

B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed plumbing fixtures and fittings.

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

END OF SECTION 22 42 00

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. 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. Included are the following topics:

1.02 REFERENCE

A. Applicable provisions of Division 1 govern this section.

B. This section applies to all Division 23 sections of HVAC.

1.03 RELATED REQUIREMENTS

A. Division 1 – General Requirements

B. Section 07 84 00 – Fire Stopping

1.04 REGULATORY REQUIREMENTS

A. All materials and workmanship shall comply with applicable Codes, local ordinances, industry standards and utility regulations. In case of differences between such Codes, and the Contract Documents, the most stringent shall govern. Promptly notify the A/E in writing of any such difference.

1.05 REFERENCE STANDARDS

A. Abbreviations

1. AABC Associated Air Balance Council
2. ABMA American Boiler Manufacturers Association
3. ADC Air Diffusion Council
4. AGA American Gas Association
5. AMCA Air Movement and Control Association
6. ANSI American National Standards Association
7. ARI Air Conditioning and Refrigeration Institute
8. ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
9. ASME American Society of Mechanical Engineers
10. ASTM American Society for Testing and Materials
11. AWWA American Water Works Association
12. AWS American Welding Society
13. CGA Compressed Gas Association
14. CTI Cooling Tower Institute
15. EPA Environmental Protection Agency
16. GAMA Gas Appliance Manufacturers Association
17. IEEE Institute of Electrical and Electronics Engineers
18. ISA Instrument Society of America
19. MCA Mechanical Contractors Association
20. MICA Midwest Insulation Contractors Association

21. MSS Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc
22. NBS National Bureau of Standards
23. NEBB National Environmental Balancing Bureau
24. NEC National Electric Code
25. NEMA National Electrical Manufacturers Association
26. NFPA National Fire Protection Association
27. SMACNA Sheet Metal and Air Conditioning Contractors' National Association. Inc.
28. UL Underwriters Laboratories Inc.

B. Standards referend in this section:
1. ASTM E814 Standard Test Method for Fire Tests of Through-Penetration Fire Stops
2. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
3. UL1479 Fire Tests of Through-Penetration Firestops
4. UL723 Surface Burning Characteristics of Building Materials

1.06 QUALITY ASSURANCE

A. Refer to Division 1, General Conditions, Equals and Substitutions.

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 for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

1.07 PERMITS, CERTIFICATES, AND INSPECTIONS

A. Obtain and pay for all required local and State construction permits.

B. Obtain and pay for all required local, State and Federal installation inspections.

C. Include copies of the certificates in the Operating and Maintenance Instructions.

1.08 ABBREVIATIONS AND SYMBOLS

A. Key to abbreviations and symbols shall be on the Drawings.

B. The following are additional abbreviations used in the Specifications.
1. A/E Architect/Engineer
2. GC General Contractor
3. PC Plumbing Contractor
4. FPC Fire Protection Contractor
5. HC Heating Ventilating and Air Conditioning Contractor
6. EC Electrical Contractor

1.09 DEFINITIONS

A. Furnish:
1. Supply and deliver to Project site ready for unpacking, assembly and installation.

B. Install:
1. Operations at Site including unpacking, assembling, erecting, placing, anchoring, applying, finishing, cleaning, and connecting related devices required for product fully functional for intended use after installation.

C. Provide:
1. Furnish and install, such that product is fully functional for intended use.

1.10 COORDINATION

A. The Drawings show the general arrangement of piping and equipment and shall be followed as closely as actual building construction and the work of other trades permits.

B. Architectural and Structural Drawings shall take precedence.

C. Because of the scale of the Drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required.

D. Investigate conditions affecting the Work and arrange accordingly, providing offsets, fittings and accessories as may be required to meet conditions.

1.11 CONTINUITY OF EXISTING SERVICES

A. Do not interrupt or change existing services without prior written approval from the owner, or facilities maintenance. When interruption is required, coordinate the down-time with the user agency to minimize disruption to their activities. Unless specifically stated, all work involved in interrupting or changing existing services is to be done during normal working hours.

1.12 PROTECTION OF FINISHED SURFACES

A. Refer to Division 1, General Requirements, Protection of Finished Surfaces.

B. Furnish one can of touch-up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

1.13 EQUIPMENT FURNISHED BY OTHERS

A. Refer to Schedules.

1.14 PROVISIONS FOR FUTURE

A. Not applicable.

1.15 OFF-SITE STORAGE

A. Any required offsite storage of material is the responsibility of the contractor. Materials or equipment damaged while stored offsite, or while transported to or from offset storage will not be allowed to be installed.

1.16 EQUIPMENT AND MATERIAL SUBMITTALS

A. Refer to Division 1, General Conditions, Submittals.

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 and/or number, as indicated in the contract documents.

C. Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the shop drawing transmittal to the architect/engineer that the equipment submitted and the motor starter schedules are in agreement or indicate any discrepancies. See related comments in Section 23 05 13 in Part 1 under Electrical Coordination.

D. Include wiring diagrams of electrically powered equipment.

E. Submit electronic (PDF) copy of all submittals for review by A/E, Architect, Owner, Owners Representative and Building Operator.

1.17 EQUIPMENT INSTALLATION

A. Drawings show general arrangement and location of equipment and appurtenances. It is Contractor's responsibility to install equipment in a location and manner that allows for proper service and maintenance access to equipment.

B. Work shall generally conform to requirements shown on Drawings. However, location of equipment may require field adjustments to obtain required service space.

C. Do not scale off of plans to determine proper location of equipment. Because of scale of Drawings, it is not possible to indicate exact routing of piping, and offsets, fittings and accessories required to provide proper service access to equipment.

D. Contractor shall route and install ductwork and piping to provide required service access to equipment.

E. If, during construction phase of Project, contractor feels inadequate space exists, or equipment locations must be substantially modified to provide proper service and maintenance access, prior to installing equipment, contractor shall notify engineer in writing, outlining general concerns and proposed modifications.

F. Equipment installed without providing manufacturer's required maintenance and service clearance shall be considered defective. Contractor shall remove and relocate piping ductwork and equipment, to provide required service clearances at contractor's expense.

1.18 OPERATION AND MAINTENANCE MANUAL

A. Provide operation and maintenance manuals at the completion of the project and prior to owner training. Operation and Maintenance Manuals shall contain the following information:
1. Table of Contents.
2. Summary sheet that includes Contractor name, Contractors contact information and name of Contractors Project Manager for the project.
3. Warranty letter.
4. Certificates of inspections by regulatory agencies.
5. Record of tests performed to comply with system and contract documents.
6. Copies of all approved submittals.
7. Lubrication instructions, including list and frequency of lubrication.
8. Manufacturer's wiring diagrams for electrically powered equipment.

9. Parts list for manufactured equipment.
10. Temperature control system record drawings
11. Startup reports.
12. Additional items as indicated in technical specification sections.

B. Provide three (3) hardcopies of the Operation and Maintenance Manual. Manuals shall be organized in three ring binders with dividers and reference tabs. Manuals shall be delivered as follows:
1. One copy to the building engineer.
2. One copy to the tenant (to be kept on site).
3. One copy to the Owners Representative.

C. Provide (3) electronic (Adobe PDF) copies of the Operation and Maintenance Manual.
1. Provide each copy on a separate portable USB flash drive.
2. Deliver each portable USB flash drive with hard copy manuals to parties listed above.

1.19 TRAINING OF OWNER PERSONNEL

A. Instruct Owner or Owners facility staff in the proper operation and maintenance of systems and equipment provided as part of this project. The Operation and Maintenance manuals shall be used and referenced during training. Provide multiple training sessions if needed due to project size and seasonal operating constraints.

B. All training times shall be coordinated with the Owner and Owners facility staff a minimum of 2 weeks prior to training.

C. Include not less than <x> hours of training instruction.

D. All training sessions shall be recorded on digital video. The contractor shall provide the recording equipment and equipment operator. Deliver (3) copies of the training video, each to be on separate flash drives to the Owner or Owners facility staff.

1.20 RECORD DRAWINGS

A. Refer to Division 1, General Requirements, Record Drawings.

B. Maintain accurate as-built or record drawings throughout the duration of the project. As-built drawings shall be available on site at all times for review by the A/E, owner or owner's representative.

C. If, during project closeout, the A/E or owner observes installations that are not accurately recorded on the as-built or record drawings, the record drawings will not be accepted and the contractor will be required, at their own expense, to provide updated and accurate record drawings.

D. In addition to the data indicated in the General Requirements, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

1.21 CLEANING

A. Keep the premises broom clean and free of surplus materials, rubbish and debris.

B. Clean all equipment, piping, duct, strainers, filters, etc. prior to building turnover to owner. All systems shall be turned over to owner in condition ready for operation.

1.22 WARRANTY

A. Warrant that work shall function for one year immediately following the acceptance of the system(s). The date of acceptance shall be an agreed upon date by all parties, including Division 23 contractor, General Contractor, Owner, Owners Representative, Tenant and A/E.

B. Keep the system in good working order at no expense, unless defects are clearly the result of improper usage.

C. Warranty calls shall be at no cost to the owner.

D. Submit for acceptance of the work, written certification that the entire system has been installed and adjusted for operation in accordance with the Contract Documents.

1.23 CERTIFIED STARTUP REPORTS

A. The Contractor shall obtain from the manufacturer of equipment in the following systems, four (4) copies of certified startup reports prepared and signed by the manufacturer's representative in responsible charge. The four copies of the startup reports shall be submitted to the A/E along with or prior to the Contractor's certification of completion. The following systems require manufacturer's startup reports:

1. Air handling unit
2. Gas-fired make-up air unit

1.24 CONSTRUCTION MEETINGS

A. Refer to Division 1, General Requirements, Record Drawings.

PART 2 - PRODUCTS [(Not Applicable)]

2.01 ACCESS PANELS AND DOORS

A. Panels shall be Milcor brand or equivalent.

B. Provide access panels at locations requiring access to mechanical equipment. Locations include, but are not limited to areas above drywall ceilings, shaft enclosures and other furred-in spaces concealing valves, ducts or equipment. Provide UL listed, fire rated access panels when penetrating fire rated chase or shaft areas.

C. Access panels shall be of size required to provide adequate access to equipment. Minimum size shall be 12 inch by 12 inch for hand access and 24 inch by 24 inch for body access.

D. Panels shall include concealed hinges, cam type locking devices, and have frame/border type necessary for particular wall or ceiling construction they are installed. Access panels shall be flush mounted, recessed frame type units. Access panels shall be prime coated steel, able to accept field painting for general applications and stainless steel for use in toilet rooms, shower rooms and similar wet areas.

E. Refer to Architectural Room Finish Schedule for wall and ceiling surfaces and finishes.

F. For non-security applications, panel construction shall utilize 16 gauge frame with not less than 18 gauge hinged door panel. Door locks shall be screwdriver operated for panels in general location applications and shall be key locked for public area applications.

G. For security area applications, panel construction shall utilize 16 gauge frame with not less than 14 gauge hinged door panel. Door locks shall be locking type. Furnish and install locking devices in accordance with types specified in Division 11.

PART 3 - EXECUTION

3.01 DEMOLITION

A. Perform all demolition as indicated on the drawings to accomplish new work. Where demolition work is to be performed adjacent to existing work that remains in an occupied area, construct temporary dust partition to minimize the amount of contamination of the occupied space. Where pipe or duct is removed and not reconnected with new work, cap ends of existing services as if they were new work. Coordinate work with the user agency to minimize disruption to the existing building occupants.

B. All pipe, wiring and associated conduit, insulation, ductwork, and similar items demolished, abandoned, or deactivated are to be removed from the site by the Contractor. All piping and ductwork specialties are to be removed from the site by the Contractor unless they are dismantled and removed or stored by the user agency. All designated equipment is to be turned over to the user agency for their use at a place and time so designated. Maintain the condition of material and/or equipment that is indicated to be reused equal to that existing before work began.

3.02 CONCRETE WORK

A. All cast-in-place concrete will be performed by the Division 3 Contractor unless otherwise noted. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for support of mechanical equipment.

3.03 CUTTING AND PATCHING

A. Refer to Division 1, General Requirements, Cutting and Patching.

B. Any cutting and patching not specifically indicated to be provided by others shall be performed by the Division 23 contractor.

3.04 ACCESS PANELS AND DOORS

A. Access panels shall be provided by the Division 08 Contractor.

B. Installation:
1. Comply with manufacturer's written instructions for installing access doors and frames.
2. Adjust doors and hardware, after installation, for proper operation.

C. Fire-Rated Door Inspections: Inspect each fire-rated access door in accordance with NFPA 80, Section 5.2.

3.05 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.

3.06 EQUIPMENT ACCESS

A. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance and service. 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. Access doors in general construction are to be furnished by the Mechanical Contractor and installed by the General Contractor.

B. Provide color coded thumb tacks or screws, depending on the surface, for use in accessible ceilings which do not require access panels.

3.07 COORDINATION

A. Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, diffusers, register, grilles, and recessed or semi-recessed heating and/or cooling terminal units installed in/on architectural surfaces.

B. Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

C. Cooperate with the test and balance agency in ensuring Section 23 05 93 specification compliance. Verify system completion to the test and balance agency (flushing, pressure testing, chemical treatment, filling of liquid systems, proper pressurization and air venting of hydronic systems, clean filters, clean strainers, duct and pipe systems cleaned, controls adjusted and calibrated, controls cycled through their sequences, etc.), ready for testing, adjusting and balancing work. Install dampers, shutoff and balancing valves, flow measuring devices, gauges, temperature controls, etc., required for functional and balanced systems. Demonstrate the starting, interlocking and control features of each system so the test and balance agency can perform its work.

D. Provide appropriate sections of work with required wall, roof and floor opening locations and dimensions. If Contractor neglects to coordinate information, openings shall be the responsibility of Contractor.

END OF SECTION 230500

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes general requirements for single-phase and polyphase motors used with equipment specified in other sections. Included are general requirements for electrical wiring and electrical connections.

1.02 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.

1.03 SUBMITTALS

A. Product Data: For each type of product.

1. Include motor manufacturer, horsepower, voltage, phase, hertz, RPM, full load efficiency, related power factor, and installation and maintenance instructions.

B. Shop Drawings: For each type of product.

1. Include wiring diagrams for motors and HVAC equipment requiring wiring by the Division 26 Contractor for Project.

1.04 GENERAL REQUIREMENTS

A. Starters, overload relay heater coils, disconnect switches and fuses, relays, wire, conduit, push-buttons, pilot lights, and other devices required for control of motors or electrical equipment will be furnished and installed by Electrical Contractor, except as specifically noted elsewhere in this Division of Specifications.

B. Refer to Drawings and Specifications for number and horsepower rating of motors furnished by Contractor, with actuating devices I devices are furnished by Division 23 Contractor.

C. Should discrepancy in size, horsepower rating, electrical characteristics, or means of control be found for motors or other electrical equipment after contracts are awarded, Contractor is to immediately notify Architect/Engineer of discrepancy.

D. Costs involved in changes required due to equipment substitutions initiated by Contractor will be responsibility of the contractor. Refer to related comments in Section 23 05 00 – Common Work Results for HVAC, under Shop Drawings.

E. Division 26 Contractor will provide line voltage power wiring.

F. HVAC contractor shall be responsible for providing control wiring (line and low voltage) for Project, including installation of interlock wiring of line and low voltage motorized automatic dampers in power roof exhaust and supply fans, sidewall centrifugal exhaust fans and propeller exhaust and supply fans to power supply wiring serving respective fan.

G. Furnish project specific wiring diagrams to Electrical Contractor for equipment, starters and devices furnished by Contractor and indicated to be wired by Electrical Contractor.

H. Provide on front enclosure face of starting equipment, selector switches and push-buttons stations, securely mounted, laminated plastic engraved name plate identifying motorized equipment served by respective starter. Refer to Section 23 05 53 “Identification for HVAC Piping and Equipment.”

1.05 PRODUCT CRITERIA

A. Motors to conform to applicable requirements of NEMA, IEEE, ANSI, and NEC standards and shall be listed by UL for service specified.

B. Select motors for conditions they will be required to perform, for example:

1. General purpose, splash-proof, explosion proof, standard duty, high torque or other special type by equipment or motor manufacturer's recommendations and as specified on Drawings and as specified herein.

C. Furnish motors for starting in accordance with utility requirements and with compatible starters as specified.

D. All motors over 1 HP shall meet minimum efficiency requirements as specified under Wisconsin Code, COMM 63.1032 requirements (Table 63.1032). Coordinate with respective supplier(s) of motors for Project to meet minimum efficiency requirements. Note special minimum motor efficiencies as specified on Drawings or within Project Specifications

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.02 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Motion Business.
   b. Eaton.
   c. Rockwell Automation, Inc.
   d. Siemens Industry, Inc., Energy Management Division.
   e. Square D; Schneider Electric USA.
   f. Or Approved Equal

2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
3. Configuration: Nonreversing
4. Surface mounting.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. ABB, Motion Business.
   c. Eaton.
   d. Rockwell Automation, Inc.
   e. Siemens Industry, Inc., Energy Management Division.
   f. Square D; Schneider Electric USA.
2. Configuration: Nonreversing .
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button ; bimetallic type .

2.03 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

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

1. ABB, Electrification Business.
2. ABB, Motion Business.
3. Eaton.
4. Rockwell Automation, Inc.
5. Siemens Industry, Inc., Energy Management Division.
6. Square D; Schneider Electric USA.
7. Or Approved Equal

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

G. Overload Relays:

1. 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.

H. Digital communication module, using RS-485 Modbus, RTU protocol, [**2**] 4-wire connection to host devices with a compatible port] to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3. Active Energy (kWh): 3-phase total.
4. Power Factor: 3-phase total.

2.04 CONTROLLER ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

2.05 CONTROLLER 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: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.
   a. Push Buttons: As indicated in the controller schedule.
   b. Pilot Lights: As indicated in the controller schedule.

B. Motor protection relays shall be with solid-state sensing circuit and isolated output contacts for hardwired connections.

1. Phase-failure.
2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.

2.06 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.

2.07 POLYPHASE MOTORS

A. Use NEMA rated, 208, 460 volt, 3 phase, 60 hertz motors.

B. Motors 1/2 hp and greater shall comply with the following, to suit starting torque and requirements of specific motor application:

C. Description: NEMA MG 1, Design B, medium induction motor.

D. Efficiency: Premium efficient, as defined in NEMA MG 1.

1. Full load efficiencies shall meet or exceed values listed below based on nominal motor speed:
2. Open Drip Proof Motors:
   a. 1 HP: 82.5% at 1,200 RPM, 85.5% at 1,800 RPM, 80.0% at 3,600 RPM
   b. 1-1/2 HP: 86.5% at 1,200 RPM, 86.5% at 1,800 RPM, 85.5% at 3,600 RPM
   c. 2 HP: 87.5% at 1,200 RPM, 86.5% at 1,800 RPM, 86.5% at 3,600 RPM
   d. 3 HP: 89.5% at 1,200 RPM, 89.5% at 1,800 RPM, 86.5% at 3,600 RPM
   e. 5 HP: 89.5% at 1,200 RPM, 89.5% at 1,800 RPM, 89.5% at 3,600 RPM
   f. 7-1/2 HP: 91.7% at 1,200 RPM, 91.0% at 1,800 RPM, 89.5% at 3,600 RPM
   g. 10 HP: 91.7% at 1,200 RPM, 91.7% at 1,800 RPM, 90.2% at 3,600 RPM
   h. 15 HP: 92.4% at 1,200 RPM, 93.0% at 1,800 RPM, 91.0% at 3,600 RPM
   i. 20 HP: 92.4% at 1,200 RPM, 93.0% at 1,800 RPM, 91.0% at 3,600 RPM
   j. 25 HP: 93.0% at 1,200 RPM, 93.6% at 1,800 RPM, 93.0% at 3,600 RPM
3. Totally Enclosed Fan Cooled Motors:
   a. 1 HP: 82.5% at 1,200 RPM, 85.5% at 1,800 RPM, 78.5% at 3,600 RPM
   b. 1-1/2 HP: 87.5% at 1,200 RPM, 86.5% at 1,800 RPM, 78.5% at 3,600 RPM
   c. 2 HP: 88.5% at 1,200 RPM, 86.5% at 1,800 RPM, 85.5% at 3,600 RPM
   d. 3 HP: 89.5% at 1,200 RPM, 89.5% at 1,800 RPM, 88.5% at 3,600 RPM
   e. 5 HP: 89.5% at 1,200 RPM, 89.5% at 1,800 RPM, 89.5% at 3,600 RPM
   f. 7-1/2 HP: 91.7% at 1,200 RPM, 91.0% at 1,800 RPM, 91.0% at 3,600 RPM
   g. 10 HP: 91.7% at 1,200 RPM, 91.7% at 1,800 RPM, 91.7% at 3,600 RPM
   h. 15 HP: 92.4% at 1,200 RPM, 92.4% at 1,800 RPM, 91.7% at 3,600 RPM
   i. 20 HP: 92.4% at 1,200 RPM, 93.0% at 1,800 RPM, 92.4% at 3,600 RPM
   j. 25 HP: 93.0% at 1,200 RPM, 93.6% at 1,800 RPM, 93.0% at 3,600 RPM

E. Service Factor: 1.15 (Open drip proof), 1.0 other motor types.

F. 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.

G. Rotor: Random-wound, squirrel cage.

H. Corrosive Atmosphere Coating:

1. For motors on the following equipment, furnish epoxy sealed or coated motor windings and protect rotor and starter surfaces with epoxy enamel. Double shield bearings; use waterproof non-washing grease.

I. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

1. Bearing to have minimum AFBMA 9, L-10 life of 200,000 hours.
2. Calculate bearing load with NEMA V-belt pully with belt center line at end of NEMA standard shaft extension.
3. Stamp bearing sizes on nameplate.

J. Temperature Rise: Class B minimum.

K. Insulation: Class F minimum.

L. 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.

M. Enclosure Material: Cast iron or rolled steel, T or U frame.

2.08 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. 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.

2.09 SINGLE-PHASE MOTORS

A. Use NEMA rated, 120 volt, single phase, 60 hertz motors.

B. Motors less than 1/2 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Capacitor start, inductor run.

C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

D. Service Factor: 1.35 minimum.

E. Insulation: Class B minimum.

F. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

G. Motors less than 1/2 hp: Shaded-pole type.

H. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation.

Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION

3.01 CONTROLLER INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height 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" unless otherwise indicated.

C. Floor-Mounted Controllers: Install controllers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. 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.

F. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.02 MOTOR INSTALLATION

A. Mount motors on rigid base designed to accept motor, using shims if required under each mounting foot to get secure installation.

B. When motors are flexible coupled to driven device, mount coupling to shafts in accordance with coupling manufacturer's recommendations. Using dial indicator, check angular misalignment of 2 shafts; adjust motor position so angular misalignment of shafts does not exceed 0.002 inches per inch diameter of coupling hub. Again using dial indicator, check shaft for run out for concentricity of shafts; adjust so run out does not exceed 0.002 inch.

C. Lubricate motors requiring lubrication. Record lubrication material used and frequency of use. Include information in Maintenance Manuals.

END OF SECTION 23 05 13

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SECTION 23 05 17

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.
4. Silicone sealants.

B. Related Requirements:

1. Section 07 84 00 " Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.02 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Pipe Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.02 SLEEVE-SEAL SYSTEMS

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

1. Flexicraft
2. Trumbell
3. GPT Industries
4. Or approved equal.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig.

3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Stainless steel
5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.03 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-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, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.04 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. Coordinate location of building surface penetrations with appropriate contractors. Furnish sleeves, inserts, and devices to be built into structure to contractor performing Work.

C. Prepare Shop Drawings for approval for penetrations of structural elements, including floor slabs, shear walls, and bearing walls. Do not allow penetrations to be made until Shop Drawings are approved.

D. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

E. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Sleeves installed in concrete to be minimum 16 gauge galvanized steel.
2. Cut sleeves to length for mounting flush with both surfaces.
3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

F. For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:

1. Pipe penetration where steel pipe sleeve is used extend steel sleeve 2” above the floor.
2. Pipe penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2” above the floor (provided it meets the device’s UL listing).
3. Pipe penetration where there is no steel sleeve or cast in place fire stopping device/sleeve, provide 2”x 2” x 1/8” galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8”on center. Seal corners water tight with urethane caulk.
4. Floors subject to water intrusion or rooms housing electrical equipment include the following locations:
    a. Restrooms
    b. Janitor Rooms w/ Sinks
    c. Mechanical/Plumbing Equipment Rooms
    d. Chemical/Hazardous Waste Storage
    e. Vehicle Storage and Parking Ramps
    f. Data/Telecommunications Rooms
    g. Electrical Equipment Rooms

G. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

H. Completely seal pipe penetrations, as specified below, for walls of the following rooms below:

1. Non-fire rated mechanical rooms
2. Data/Telecommunications rooms
3. Private offices

I. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 84 00 "Firestopping."

1. UL listed or tested by independent testing laboratory, approved by State and Local Code jurisdictions. Use a product that has a rating not less than rating of wall or floor being penetrated. Sleeves in concrete to be minimum 16 gauge galvanized steel sleeves.
2. Install products in accordance with the manufacturer's instructions where pipe penetrates a fire rated surface.
3. When pipe is insulated, use product that maintains integrity of insulation and vapor barrier.
4. Where sleeve must be installed in existing floor, grout area around sleeve to restore floor integrity.
5. In wet area floor penetration, top surface of penetration to be 2 inches above adjacent floor with additional height obtained by means of concrete pad poured integral with floor. Wet areas for this Paragraph are rooms or spaces containing air handling unit coils, convertors, pumps, chillers, boilers, and similar equipment.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.04 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:
   a. Piping Smaller Than NPS 6: Steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Steel-pipe sleeves.
2. Exterior Concrete Walls Below Grade:
   a. Piping Smaller Than NPS 6: Sleeve-seal fittings.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Sleeve-seal fittings.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6 : Steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Steel-pipe sleeves with sleeve-seal system.
4. Concrete Slabs Above Grade:
   a. Piping Smaller Than NPS 6: Steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Steel-pipe sleeves.
5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Galvanized-steel pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 23 05 17

SECTION 23 05 18

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

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

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

2.02 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.01 INSTALLATION

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

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

1. Escutcheons for New Piping
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece deep pattern.
   b. Insulated Piping: One-piece steel with polished, chrome-plated finish.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

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

1. New Piping: Split floor plate.

END OF SECTION 23 05 18

SECTION 23 05 20

VARIABLE FREQUENCY DRIVES

1.01 RELATED DOCUMENTS

A. Section 23 05 00 "Common Work Results for HVAC".

B. Section 23 09 23 "Direct Digital Control (DDC) System for HVAC".

C. Applicable sections in Division 26.

1.02 SUMMARY

A. Section includes variable frequency drives consisting of a pulse width modulated (PWM) inverter designed for use with both asynchronous and permanent magnet motors.

1.03 REFERENCE STANDARDS

A. ANSI/IEEE – Guide for Harmonic Controls and Reactive Compensation of Static Power Converters

B. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

C. NEMA ICA 7-2014 – Adjustable Speed Drives

D. NFPA 70 – National Electrical Code (NEC)

1.04 SUBMITTALS

A. Product Data: For each VFD indicated.

1. Include dimensions and finishes for VFDs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFD indicated.

1. Include mounting and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Product Certificates: For each VFD from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs 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 and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings and overload settings as applicable.
   b. Manufacturer's written instructions for setting field-adjustable overload relays.
   c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
   e. Start-up report for each VFD listing complete procedures and tests performed.
   f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.06 MAINTENANCE MATERIAL SUBMITTALS

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

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.07 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by the manufacture.

1. Testing Agency's Field Supervisor: Certified by the manufacture to supervise on-site testing. Submit manufacture’s approved start-up report and certification credentials

1.08 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, including clearances between VFDs, and adjacent surfaces and other items.

1.09 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period of 1 year from the date of shipment. The warranty shall include parts, labor and travel.

2.01 MANUFACTURERS

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

1. Danfoss
2. Or approved equal.

2.02 SYSTEM DESCRIPTION

A. General Requirements for VFDs:

1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, UL labeled as a complete assembly, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL508A.

B. Application: Variable torque per the application requirements.

C. VFD Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means, fuses and overload protection; listed and labeled by UL a complete unit.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current rating of 100KA by UL 508A.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 5 percent of VFD frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).

9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus **5** percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 10:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2. Provide phase to phase and phase to ground protection.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips. (-35% and +30%)
4. Inverter overcurrent trips and ground fault protection (start and running).
5. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is engaged.

M. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: Door interlocked switch and fuses with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 125 percent of VFD input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. [NC] [NO] alarm contact that operates only when circuit breaker has tripped.

2.03 PERFORMANCE REQUIREMENTS

2.04 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Door-Mounted Operator Station: Manufacturer's front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability. All drives shall utilize the same (keypad) user interface

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
   a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time, fan operation time, power up time
4. Fault log, maintaining last four faults with time and date stamp for each.
5. Event log, last 10 operating changes with date and time stamps.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

1. Output frequency (Hz).

2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (no codes).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).
11. Status of digital and analog inputs and outputs
12. The control panel shall include at minimum the followings controls:
    a. Four navigation keys (Up, Down, Left, Right) and two soft keys.
    b. Hand-Off-Auto selection, Fault Reset, and manual speed control.

E. A Help key shall include assistance for programming and troubleshooting

F. Control Signal Interfaces:

1. Electric Input Signal Interface:
    a. A minimum of two programmable analog inputs: 4- to 20-mA dc
    b. A minimum of six multifunction programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
    a. 0- to 10-V dc.
    b. 4- to 20-mA dc.
    c. Potentiometer using up/down digital inputs.
    d. Fixed frequencies using digital inputs.
3. Output Signal Interface: A minimum of one programmable analog output signal(s) 4- to 20-mA dc, which can be configured for any of the following:
    a. Output frequency (Hz).
    b. Output current (load).
    c. DC-link voltage (V dc).
    d. Motor torque (percent).
    e. Motor speed (rpm).
    f. Set point frequency (Hz).
4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    a. Motor running.
    b. Set point speed reached.
    c. Fault and warning indication (overtemperature or overcurrent).
    d. PID high- or low-speed limits reached.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained within VFD's nonvolatile memory. MSTP BACnet (BTL Listed), Modbus and N2 bus shall be supported as standard.

1. Hardwired Points:
    a. Monitoring: On-off status.
    b. Control: On-off operation.
2. Communication Interface: Comply with ASHRAE 135 Communication shall interface with DDC system for HVAC to remotely control and monitor from a DDC system for HVAC operator workstation.

2.05 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations. The minimum filtering shall be a 5% impedance from AC line reactors or dual DC bus reactors. Micro drives are not acceptable.

B. Output Filtering: N/A

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

D. EMI/RFI Filtering: N/A

2.06 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFD suitable for variable-speed service to multiple motors. Overload protection shuts down VFD and motors served by it and generates fault indications when overload protection activates.

1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

B. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFD resumes normal operation.

C. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

D. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.07 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. All locations Type 4X.

2.08 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.

1. Push Buttons: Lockable.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.
4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. [NC] [NO] [Reversible NC/NO] bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250,Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, Type 4X; UL 508 component recognized: Supply fan, with intake and exhaust grills and filters ; 120 V ac; obtained from integral CPT.

I. Spare control-wiring terminal blocks ; wired.

2.09 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.

1. Test each VFD while connected to its specified motor.
2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

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

C. Prepare test and inspection reports.

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.02 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in each fusible-switch VFC.

D. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

E. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

F. Comply with NECA 1.

3.03 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Section 26 05 23 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.04 IDENTIFICATION

A. Identify VFDs, 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 each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.05 FIELD QUALITY CONTROL

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

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. Test and adjust controllers, components, and equipment.
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 ASHARE 90.1 Section 8.4 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. 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.

3.06 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.

3.07 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges coordinating with electrical contractor Short-Circuit and Coordination Studies.

3.08 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.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION 23 05 20

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SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Metal framing systems.
5. Fastener systems.
6. Equipment supports.
7. Corrosive atmosphere coatings.
8. Roof mounted supports.
9. Equipment curbs.
10. Pipe penetrations through roof.

B. Related Requirements:

1. Section 05 50 00 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 23 05 48.13 "Vibration Controls for HVAC" for vibration isolation devices.
3. Section 23 31 13 "Metal Ducts" for duct hangers and supports.

1.02 SUBMITTALS

A. Product Data: For each type of product.

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

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

1.03 INFORMATIONAL SUBMITTALS

1.04 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, Section IX.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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

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

2.02 PIPE HANGER AND SUPPORT MANUFACTURERS

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

1. Anvil, B Line, Fee and Mason, Kindorf, Michigan Hanger, Unistrut, or approved equal.

2.03 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
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. Stainless Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

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

2.04 TRAPEZE PIPE HANGERS

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

2.05 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers:

1. Buckaroos, CADDY, Pipe Shields, Rilco Manufacturing, or approved equal.

B. Insulation-Insert Material for Cold Piping: ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

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

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

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

2.06 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped 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 galvanized steel.
7. Metallic Coating: Hot-dip galvanized.
8. Paint Coating: Green epoxy, acrylic, or urethane.

2.07 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or 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.

2.08 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper B-line; brand of Eaton, Electrical Sector.
   b. Hilti, Inc.
   c. Mason Industries, Inc.
   d. Powers Fasteners.
   e. Simpson Strong-Tie Co., Inc.
   f. Unistrut; Atkore International.

2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.

1. Undercut expansion anchors are permitted.

2.09 CONCRETE INSERTS

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

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.
5. Simpson Strong-Tie Co., Inc.
6. Unistrut; Atkore International.

B. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

2.10 EQUIPMENT SUPPORTS

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

2.11 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

2.12 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.

B. Mechanically galvanized 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.

C. Corrosive atmospheres include the following:

1. Exterior locations.

2.13 ROOF MOUNTED SUPPORTS

A. Height of Supports:

1. Based on the length of the longest main support member, the height of the support member above the roof deck to be as follows:
   a. Length of longest support member up to 36 inch; 18 inch minimum height of support above roof.
   b. Length of longest support member 37” and greater; 36 inch minimum height of support above roof.

B. Supports of 18 inch or less in Height:

1. Prefabricated Metal Sleeper Curb
   a. Constructed of not less than 18 gauge galvanized steel reinforced so it is structurally capable of supporting the intended load with no penetrations through the curb flashing, inside and outside corner sections that are mitered and continuously welded, filled with 3 pound density rigid fiberglass insulation, integral deck mounting flange, nominal two inch wood nailer, galvanized steel counter flashing with metal receiver cap Attach a galvanized steel channel track for securing pipe or duct roller and roller support.
   b. Do not use built-in metal base flashings or cants.
2. Wood Build Sleep Curb
   a. Use galvanized structural steel members supported by pipe supports and use pipe or duct rollers fastened to the structural member. Pipe supports to be secured to the roof structure and sealed per pipe penetrations through roof specifications as specified in this section.

C. Supports of 36 inch or greater in Height:

1. Roof Support Stand/Equipment Roof Support Stand:
   a. Use galvanized structural steel members supported by pipe supports and use pipe or duct rollers fastened to the structural member. Pipe supports to be secured to the roof structure and sealed per pipe penetrations through roof specifications as specified in this section.

D. Pipe Supports

1. Manufacturer: Subject to compliance with these specifications, pipe support systems shall be DURA-BLOK design as supplied by Eaton or engineer approved equal.

2. Materials:
   a. Curb base must be made of 100% recycled rubber and polyurethane prepolymer with a uniform load capacity of 500 pounds per linear foot of support.
   b. Dimensions: Provide minimum size to support piping per manufacturer recommendations.
   c. Steel frame: Steel, strut galvanized per ASTM A653 or strut galvanized per ASTM A653 for bridge series.
   d. Attaching hardware: Zinc-plated threaded rod, nuts and attaching hardware per ASTM B6333.
3. Type of rooftop supports:
   a. Rubber block supports – DURA-BLOK. Accessories are fastened directly into rubber material with weather resistant type 12 lag screws.
   b. Continuous block channel supports – DURA-BLOK DB Series or DB6 Series: Assembly has 1" gaps between blocks for free flow of water. Standard strut accessories can be used for attachment.
   c. Bridge channel supports – DURA-BLOK DB10 Series; Standard strut accessories can be used for attachment.
   d. Extendible height support – DURA-BLOK,height to suit application: 8-inch, 12-inch or 16-inch (200 pound maximum load). Base to be 9.6 inches in length or otherwise specified sizes available. Heavier loads, may require CLDP load distribution plate.
   e. Roller supports– DURA-BLOK DBR10 Series & DBR Series.

2.14 EQUIPMENT CURBS

A. Prefabricated Metal Curb

1. Construction: Minimum 18 gauge reinforced galvanized steel. Continuously welded mitered inside and outside corner sections.
2. Insulation: Minimum 3 lb/cu. ft. rigid fiberglass
3. Height: Minimum 18 inch.
4. Size: Curb to be large enough to surround the perimeter of the equipment.
5. Accessories:
   a. Integral deck mounting flange
   b. Nominal 2 inch wood nailer
   c. Galvanized steel counter flashing

2.15 PIPE PENETRATIONS THROUGH ROOF

A. Multiple Pipe Penetrations:

1. Provide minimum 8 inch height equipment curb with coping cap.
2. Coping Cap: Laminated acrylic clad thermoplastic (ABS) with graduated step boots to accommodate various pipe sizes.
3. Fasteners: Stainless steel screws for cover, stainless steel band clamps for securing boots around pipe, and stainless steel band clamp or mechanical locking seal for securing boots around ABS coping cap flanges.

B. Single Pipe Penetrations

1. Provide a stack flashing penetration through built up roofs or single ply membrane roofs.
2. Utilize high temperature sealant for all high temperature applications.
3. A single pre-manufactured boot may be utilized for single pipe penetrations through single ply membrane roofs only.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.02 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. 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-58. 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 A36/A36M, 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 strut systems.

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

E. Fastener System Installation:

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

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 "Roof Accessories" for curbs.

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

H. Piping shall be supported independently from ductwork and all other trades.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

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

L. Place a hanger within 12 inches of each horizontal elbow, valve, strainer, or similar piping specialty item.

M. Support riser piping independently of connected horizontal piping.

N. 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.

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

P. 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.

Q. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 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.

3.04 ROOF MOUNTED SUPPORTS

A. Use for all ductwork and pipe on roof. Secure bottom of support flat on roof deck. Apply two coats of zinc rich paint to cut edges of all galvanized steel elements. Flashing and counter flashing by the General Contractor.

B. Pipe Supports

1. Install in accordance with manufacturer's instructions and recommendations.
2. If gravel top roof, gravel must be removed around and under pipe support.
3. Always consult roofing manufacturer for roof membrane compression capacities. If necessary, a compatible sheet of roofing material (rubber pad) may be installed under rooftop support to disperse concentrated loads and add further membrane protection.
4. Gas pipe spacing subject to local gas authorities.
5. Use properly sized clamps to suit pipe sizes.

3.05 EQUIPMENT CURBS

A. Secure bottom of support flat on roof deck.

B. Secure equipment to curb in accordance with equipment manufacturer's instructions.

C. Flashing and counter flashing by the General Contractor.

D. Fill the entire void space with compressible fiberglass insulation.

3.06 PIPE PENETRATIONS THROUGH ROOF

A. Install at points where pipes penetrate roof.

B. Install as shown on the drawings, as detailed and according to the manufacturer's installation instructions.

C. Flashing and counterflashing by the General Contractor.

3.07 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.

3.08 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.

3.09 PAINTING

A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.10 HANGER AND SUPPORT SCHEDULE

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

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

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

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

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless steel pipe hangers and stainless steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

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

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.

4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

END OF SECTION 23 05 29

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SECTION 23 05 48.13

VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads. (Type 1)
2. Elastomeric isolation mounts. (Type 2)
3. Open-spring isolators. (Type 3)
4. Restrained-spring isolators. (Type 4)
5. Spring hangers with Neoprene. (Type 5)
6. Precompressed Spring hangers with Neoprene. (Type 6)
7. Spring hangers with Deflection Indicator. (Type 7)
8. Elastomeric hangers. (Type 8)
9. Restrained-air-spring isolators. (Type 9)
10. Housed-spring isolators. (Type 10)
11. Pipe-riser resilient support. (Type AG)
12. Snubbers.
13. Restraints - rigid type.
14. Restraints - cable type.
15. Restraint accessories.
16. Post-installed concrete anchors.
17. Concrete inserts.

B. Related Requirements:

1. Section 21 05 48.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 22 05 48.13 "Vibration Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.03 DEFINITIONS

A. IBC: International Building Code.

1.04 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-force-restraint fitting and assembly.

3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and wind-force-restraint component.
4. Annotate to indicate application of each product submitted and compliance with requirements.
5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
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. Welding certificates.

1.05 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with requirements in "Vibration Isolation Schedule, General," in Part 3 Execution for where vibration isolation devices are applied.

B. Consequential Damage: Provide additional restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in ASCE so that failure of a non-essential or essential HVAC component will not cause the failure of any other essential architectural, mechanical, or electrical building component.

C. Fire/Smoke Resistance: All components that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

D. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.

2.02 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads: **Type 1**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Isolation Technology, Inc.
   c. Kinetics Noise Control, Inc.
   d. Korfund.
   e. Mason Industries, Inc.
   f. NOVIA; a division of Carpenter & Paterson.

g. Vibration Eliminator Co., Inc.
h. Vibration Isolation.
i. Vibration Management Corp.
j. VMC GROUP.

2. Fabrication: Single or multiple layers of 40 durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Minimum deflection as indicated below in the performance section.
5. Pad Material: Oil- and water-resistant rubber.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
   a. Infused nonwoven cotton or synthetic fibers.

2.03 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts: **Type 2**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Isolation Technology, Inc.
   c. Kinetics Noise Control, Inc.
   d. Korfund.
   e. Mason Industries, Inc.
   f. NOVIA; a division of Carpenter & Paterson.
   g. Vibration Eliminator Co., Inc.
   h. Vibration Isolation.
   i. Vibration Management Corp.
   j. VMC GROUP.
2. Mounting Plates:
   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Minimum deflection as indicated below in the performance section.
4. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.04 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: **Type 3**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Isolation Technology, Inc.
   c. Kinetics Noise Control, Inc.
   d. Korfund.
   e. Mason Industries, Inc.
   f. NOVIA; a division of Carpenter & Paterson.
   g. Vibration Eliminator Co., Inc.
   h. Vibration Isolation.
   i. Vibration Management Corp.
   j. VMC GROUP.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
8. Minimum deflection as indicated below in the performance section.

2.05 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: Type 4

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Isolation Technology, Inc.
   c. Kinetics Noise Control, Inc.
   d. Korfund.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Management Corp.
   i. VMC GROUP.
2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
   b. Top plate as required.
   c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Minimum deflection as indicated below in the performance section.

2.06 SPRING HANGERS WITH NEOPRENE

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: **Type 5**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. NOVIA; a division of Carpenter & Paterson.
   e. Vibration Eliminator Co., Inc.

f. Vibration Isolation.
g. Vibration Management Corp.
h. VMC GROUP.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Minimum deflection as indicated below in the performance section.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Thrust Support: When air thrust exceeds 10 percent of equipment weight, provide **Type 3** with same deflection as specified for the mounting or hanger.
    a. Design assembly so spring element is contained within steel frame, so it can be preset for thrust at factory, and adjusted in field for maximum of ¼ inch movement at start and stop.
    b. Include threaded rod and angle brackets for attachment to both equipment and ductwork or equipment and structure.
11. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.07 PRECOMPRESSED SPRING HANGERS WITH NEOPRENE

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: **Type 6**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.
    d. NOVIA; a division of Carpenter & Paterson.
    e. Vibration Eliminator Co., Inc.
    f. Vibration Isolation.
    g. Vibration Management Corp.
    h. VMC GROUP.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
    a. Pre-compress spring to rated deflection to keep piping or equipment at fixed elevation during installation.
    b. Hanger to have release mechanism to free spring after the installation is complete and hanger is subjected to full 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. Minimum deflection as indicated below in the performance section.

7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Thrust Support: When air thrust exceeds 10 percent of equipment weight, provide **Type 3** with same deflection as specified for the mounting or hanger.
    a. Design assembly so spring element is contained within steel frame, so it can be preset for thrust at factory, and adjusted in field for maximum of ¼ inch movement at start and stop.
    b. Include threaded rod and angle brackets for attachment to both equipment and ductwork or equipment and structure.
11. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.08 SPRING HANGERS WITH DEFLECTION INDICATOR

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression with deflection indicator: **Type 7**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. California Dynamics Corporation.
    b. Kinetics Noise Control, Inc.
    c. Mason Industries, Inc.
    d. NOVIA; a division of Carpenter & Paterson.
    e. Vibration Eliminator Co., Inc.
    f. Vibration Isolation.
    g. Vibration Management Corp.
    h. VMC GROUP.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Minimum deflection as indicated below in the performance section.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Deflection Indicator Scale: provide on hangers supporting vertical piping.
11. Thrust Support: When air thrust exceeds 10 percent of equipment weight, provide **Type 3** with same deflection as specified for the mounting or hanger.
    a. Design assembly so spring element is contained within steel frame, so it can be preset for thrust at factory, and adjusted in field for maximum of ¼ inch movement at start and stop.
    b. Include threaded rod and angle brackets for attachment to both equipment and ductwork or equipment and structure.

12. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.09 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: **Type 8**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. NOVIA; a division of Carpenter & Paterson.
   e. Vibration Eliminator Co., Inc.
   f. Vibration Isolation.
   g. Vibration Management Corp.
   h. VMC GROUP.
2. Frame: 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. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
4. Minimum deflection as indicated below in the performance section.

2.10 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint: **Type 9**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Firestone Industrial Products Company.
   b. Mason Industries, Inc.
   c. Vibration Management Corp.
2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
   b. Top plate with [threaded mounting holes] [elastomeric pad].
   c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Minimum deflection as indicated below in the performance section.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
9. Maximum Natural Frequency: 3 Hz.
10. Operating Pressure Range: 25 to 100 psi.
11. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
12. Automatic leveling valve.

2.11 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: **Type 10**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Isolation Technology, Inc.
   c. Kinetics Noise Control, Inc.
   d. Korfund.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Management Corp.
   i. VMC GROUP.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum deflection as indicated below in the performance section.
7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
   b. Top housing with [attachment and leveling bolt] [threaded mounting holes and internal leveling device] [elastomeric pad].

2.12 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- Thick Neoprene: **Type AG**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. Vibration Eliminator Co., Inc.
   e. Vibration Management Corp.
2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
3. Maximum Load Per Support: 500 psi on isolation material providing equal isolation in all directions.
4. Minimum deflection as indicated below in the performance section.

2.13 SNUBBERS

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

1. Kinetics Noise Control, Inc.

2. Mason Industries, Inc.
3. Vibration Management Corp.
4. VMC GROUP.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI.
2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.14 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper B-line; brand of Eaton, Electrical Sector.
   b. Hilti, Inc.
   c. Mason Industries, Inc.
   d. Powers Fasteners.
   e. Simpson Strong-Tie Co., Inc.
   f. Unistrut; Atkore International.
2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.

1. Undercut expansion anchors are permitted.

2.15 CONCRETE INSERTS

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

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.

5. Simpson Strong-Tie Co., Inc.
6. Unistrut; Atkore International.

B. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

2.16 ISOLATION DEFLECTION SCHEDULE

A. PERFORMANCE

	Floor Span or Column Spacing							
	--On Grade--		---20 Feet---		---30 Feet---		---40 Feet---	
TYPE OF EQUIPMENT	Iso.	Min. Static Defl.	Iso.	Min. Static Defl.	Iso.	Min. Static Defl.	Iso.	Min. Static Defl.
Air-cooled Condenser	Bolt to pad		3	0.75	3	1.50	3	2.50
Air-cooled Condensing Units	Bolt to pad		3	0.75	4	1.50	4	2.50

Square in-line, Tubular Centrifugal and Axial Fans

Suspended — Use Type 5-T hangers with deflection from blower minimum deflection guide. Type T needed only when air thrust exceeds 10 percent of equipment weight.

Floor mounted — 3-IB for arrangement 1 with deflection from blower minimum deflection guide.

Cabinet Fans, Evaporative Coolers, and fan sections of air handling units

Suspended — Type 5-T supports with deflection from blower minimum deflection guide. Type T needed only when air thrust exceeds 10 percent of equipment weight.

Floor mounted — Type 2-T for 0.35 inch deflection, Type 3-T for 0.75 inch deflections and Type 3-S-T for deflections over 0.75 inch with deflection from blower minimum deflection guide.

Piping connected to Equipment

Flexible piping connections.

For special systems, as designated on Drawings, equipment shall have both flexible piping connections and Type 5 or 6 hangers for a distance of 100 pipe diameters, or a distance of 3 hangers away from reciprocating equipment, whichever is greater.

Where piping is floor supported, the above requirement applies, but use Type 3 mounts instead of Type 5 or 6 hangers.

Ductwork in mechanical rooms	Use Type 8 hanger with .75 inch minimum deflection for ducts with cross sectional area greater than 2.0 square feet and, where either air equipment rooms velocity is greater than 3500 fpm or, pressure class is 4 inch" water column or higher.

B. BLOWER DEFLECTION GUIDE

	Required Deflection (Inches)			
Fan Speed (RPM)	On Grade	20' Floor Span	30' Floor Span	40' Floor Span
175-224	0.35	3.50	4.50	4.50
225-299	0.35	3.50	3.50	3.50
300-374	0.35	2.50	2.50	3.50
375-499	0.35	1.50	2.50	3.50
500 and over	0.35	0.75	1.50	2.50

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and wind-load 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.

3.02 APPLICATIONS

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

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

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.03 INSTALLATION OF VIBRATION CONTROL DEVICES

A. Provide vibration control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules below, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 "Cast-in-Place Concrete."

C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Do not allow installation practices to short circuit isolation devices.

E. Comply with requirements in Section 07 72 00 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

F. Equipment Restraints:

1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

G. Piping Restraints:

1. Install flexible piping connections on the equipment side of shut off valves.
2. Comply with requirements in MSS SP-127.
3. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
4. Brace a change of direction longer than 12 feet.

H. Install wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

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

J. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

L. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole

and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL MOTION

A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7.

3.05 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

B. Coordinate dimensions of equipment bases with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate isolated equipment.

3.06 FLEXIBLE PIPING CONNECTIONS

A. Provide flexible piping connections for equipment specified to have vibration isolation devices installed and as shown on Drawings.

B. Flexible piping connections shall be located between isolation valves and the equipment served.

C. Pipe supports or hangers located between the flexible piping connection and the equipment shall also be provided with vibration isolation devices.

3.07 ADJUSTING

A. Adjust isolators after system is at operating weight.

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

3.08 FIELD QUALITY CONTROL

A. Testing Agency: 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. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least [**four**] of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

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

E. Prepare test and inspection reports.

END OF SECTION 23 05 48.13

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.

1.02 SUBMITTALS

A. Product Data: For each type of product.

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

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Stenciling for Equipment:

1. Not less than 1 inch high letters or numbers for marking equipment.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation
   b. Emedco
   c. Seton Identification Products
   d. Or approved equal.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
3. Letter and Background Color: As indicated for specific application under Part 3.
4. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.

C. 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.

2.02 WARNING SIGNS AND LABELS

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

1. Brady Corporation
2. Emedco
3. Seton Identification Products
4. Or approved equal.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

C. Letter and Background Color: As indicated for specific application under Part 3.

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

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

G. Fasteners: Stainless steel rivets or self-taping screws.

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

I. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

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

2.03 PIPE LABELS

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

1. Brady Corporation
2. Emedco
3. Seton Identification Products
4. Or approved equal.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

C. Letter and Background Color: As indicated for specific application under Part 3.

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

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

F. Stenciled Pipe Labels: Not less than 1 inch high letters and numbers for marking piping.

G. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping .

2.04 DUCT LABELS

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

1. Brady Corporation
2. Emedco
3. Seton Identification Products
4. Or approved equal.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter and Background Color: As indicated for specific application under Part 3.

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

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

G. Fasteners: Stainless steel rivets or self-tapping screws.

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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION, GENERAL 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.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.03 EQUIPMENT AND PIPE STENCILNG

A. Identify equipment in mechanical equipment rooms and above ceilings, including air terminal units and terminal heating devices by stenciling equipment number and service with 1 coat of black enamel against light background or white enamel against dark background.

1. Air terminal units to be labeled on bottom and side of unit.

B. Identify rooftop or grade mounted equipment by stenciling equipment number with 1 coat of black enamel.

C. Use primer where necessary for proper paint adhesion. Do not label equipment in occupied spaces (for example cabinet heaters and ceiling fans).

D. Where stenciling is not appropriate for equipment identification, engraved nameplates shall be used.

E. Identify pipe by stenciling with 1 coat of black enamel on insulated piping and 1 coat of white enamel on non-insulated piping. Identify the following:

1. System Name
2. Flow Arrows

3.04 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Provide labels to identify control equipment and motor starters. Motor starters shall be provided with engraved label identifying piece of equipment in serves by plan identification.

C. Identify fire and smoke dampers. Dampers shall be permanently identified on exterior of duct with label (or painted) having a minimum letter height of 1 inch. Identification shall read either ”FIRE DAMPER”, “ SMOKE DAMPER” or “FIRE/SMOKE DAMPER”.

D. Sign and Label Colors:

1. White letters on an ANSI Z535.1 safety-blue background.

E. Locate equipment labels where accessible and visible.

F. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.05 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

B. 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. Within 3 ft. of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

D. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Pipe-Label Color Schedule:

1. Refrigerant Piping: White letters on an ANSI Z535.1 safety-blue background.

3.06 INSTALLATION OF DUCT LABELS

A. Install plastic-laminated self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:
   a. For air supply ducts: White letters on blue background.
   b. For air return ducts: White letters on blue background.
   c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.

END OF SECTION 23 05 53

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:
   a. Variable-air-volume systems.
2. Testing, adjusting, and balancing of equipment.
3. Duct leakage tests verification.
4. HVAC-control system verification.

1.02 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. TAB: Testing, adjusting, and balancing.

C. TABB: Testing, Adjusting, and Balancing Bureau.

D. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

E. TDH: Total dynamic head.

1.03 DESCRIPTION

A. The Contractor will separately contract with an independent test and balance agency to perform all testing, adjusting, and balancing of air systems required for this project. Work related to the testing, adjusting, and balancing that must be performed by the installing mechanical contractor is specified in other section of these specifications.

B. Provide total mechanical systems testing, adjusting and balancing. Requirements include the balance of air distribution, adjustment of new systems and equipment to provide design requirements indicated on the drawings, electrical measurement and verification of performance of all mechanical equipment, all in accordance with standards published by AABC, NEBB, or TABB.

C. Test, adjust and balance all air systems so that each room or piece of equipment meets the design requirements indicated on the drawings and in the specifications.

D. Accomplish testing, adjusting and balancing work in a timely manner that allows partial occupancy of major buildings, occupancy of one building when the project involves many buildings, and completion of the entire project in the time stated in the Instruction to Bidders and in accordance with the completion schedule established for this project.

E. Verify that provisions are being made to accomplish the specified testing, adjusting and balancing work. If problems are found, handle as specified in Part 3 under Deficiencies.

1.04 SUBMITTALS

A. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

B. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

C. Certified TAB reports.

D. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.05 QUALITY ASSURANCE

A. An independent Firm specializing in the Testing and Balancing of HVAC systems for a minimum of 3 years.

1. A Firm not engaged in the commerce of furnishing or providing equipment or material generally related to HVAC work other than that specifically related to installing Testing and Balancing components necessary for work in this section such as, but not limited to sheaves, pulleys, and balancing dampers.

B. The firm shall be a certified member of AABC or certified by NEBB or TABB in the specific area of work performed.

1. Maintain certification for the entire duration of the project. If certification of firm or any staff performing work is terminated or expires during the duration of the project, contact A/E immediately.

C. Technicians on this project must have satisfactorily completed work on a minimum of (3) three projects of at least 50% in size, and of similar complexity.

1. Size is defined as the quantity of each specific individual item requiring testing and balancing such as, but not limited to, equipment, devices, terminal devices, and grilles and diffusers.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

F. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.06 FIELD CONDITIONS

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

1.07 PRE-INSTALLATION MEETING AND SCHEDULING

A. The test and balance agency is required to attend a pre-installation meeting with all other project contractors before the construction process is started.

1. The test and balance agency shall give the Lead Contractor a detailed schedule of testing and balancing tasks for incorporation into the project schedule.
2. Reference General Conditions Article 12 for Lead Contractor responsibilities for scheduling.

1.08 PRE-BALANCE CONFERENCE

A. 90 days prior to beginning testing, adjusting and balancing, schedule and conduct a conference with the Architect/Engineer, Owner’s Project Representative and the mechanical system and temperature control system installing Contractors.

B. Provide AE and Commissioning Provider (CxP) with a complete copy of the TAB plan for the project.

C. The objective is final coordination and verification of system operation and readiness for testing, adjusting and balancing procedures and scheduling procedures with the above mentioned parties.

D. Indicate work required to be completed prior to testing, adjusting, and balancing and identify the party responsible for completion of that work.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION

A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements to be in accordance with the requirements of NEBB, AABC, or TABB Standards and instrument manufacturer's specifications.

B. All instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by A/E upon request. Calibration and maintenance of all instruments to be in accordance with the requirements of NEBB, AABC, or TABB Standards

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

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

E. Examine 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 verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine heat-transfer coils for clean and straight fins.

J. Examine operating safety interlocks and controls on HVAC equipment.

K. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

L. Examine filters for cleanliness.

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.

3.02 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:
   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.

b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Unless specifically instructed in writing, all work in this specification section is to be performed during the normal workday.

C. Cut insulation, ducts and equipment casings 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. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 23 07 13 "Duct Insulation," Section 23 07 16 "HVAC Equipment Insulation," and Section 23 07 19 "HVAC Piping Insulation."

D. 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.

E. Take and report testing and balancing measurements in inch-pound (IP) units.

F. Leave systems in proper working order, replacing belt guards, closing access doors and electrical boxes, and restoring temperature controls to normal operating settings.

G. Contact the temperature control Contractor for assistance in operation and adjustment of controls during testing, adjusting and balancing procedures. Cycle controls and verify proper operation and setpoints. Include in report description of temperature control operation and any deficiencies found.

3.04 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

1. Motors.
2. Fans and ventilators.
3. Radiant heaters.
4. Unit heaters.
5. Condensing units.

6. Energy-recovery units.
7. Air-handling units.
8. Heating-only makeup air units.
9. Split-system air conditioners.
10. Heat pumps.

3.05 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.

c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
d. Adjust controls so that terminal is calling for minimum airflow.
e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

6. Measure fan static pressures as follows:
a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
a. Balance the return-air ducts and inlets.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.

9. Verify final system conditions as follows:
a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, speed, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.07 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.08 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.09 PROCEDURES FOR AIR-COOLED CONDENSERS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of fan(s) and motor(s).

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Air pressure drop.
5. Voltage and amperage input of each phase at full load.
6. Calculated kilowatt at full load.
7. Fuse or circuit-breaker rating for overload protection.

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. Airflow.
4. Air pressure drop.
5. Entering and leaving refrigerant pressure and temperatures.

3.11 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.12 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.13 TOLERANCES

A. Set HVAC system's airflow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: 0 to 10 percent. If design value is less than 100 cfm, within 10 cfm.
2. Air Outlets and Inlets: 0 to 10 percent. If design value is less than 100 cfm, within 10 cfm.
3. Room Pressurization Air: Plus or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.14 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.15 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Variable-frequency controller settings for variable-air-volume systems.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Terminal units.
4. Balancing stations.
5. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and speed.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan speed.
   d. Inlet and discharge static pressure in inches wg.
   e. For each filter bank, filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches wg.
   g. Cooling-coil static-pressure differential in inches wg.
   h. Heating-coil static-pressure differential in inches wg.
   i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
   j. Outdoor airflow in cfm.
   k. Return airflow in cfm.
   l. Outdoor-air damper position.
   m. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft..
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.

g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Refrigerant expansion valve and refrigerant types.
i. Refrigerant suction pressure in psig.
j. Refrigerant suction temperature in deg F.

G. 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 speed.
   k. Motor volts, phase, and hertz.
   l. Motor full-load amperage and service factor.
   m. Sheave make, size in inches, and bore.
   n. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Entering-air temperature in deg F.
   c. Leaving-air temperature in deg F.
   d. Air temperature differential in deg F.
   e. Entering-air static pressure in inches wg.
   f. Leaving-air static pressure in inches wg.
   g. Air static-pressure differential in inches wg.
   h. Low-fire fuel input in Btu/h.
   i. High-fire fuel input in Btu/h.
   j. Manifold pressure in psig.
   k. High-temperature-limit setting in deg F.
   l. Operating set point in Btu/h.
   m. Motor voltage at each connection.
   n. Motor amperage for each phase.
   o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in Btu/h.
   e. Number of stages.
   f. Connected volts, phase, and hertz.
   g. Rated amperage.
   h. Airflow rate in cfm.
   i. Face area in sq. ft..
   j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):
   a. Heat output in Btu/h.
   b. Airflow rate in cfm.
   c. Air velocity in fpm.
   d. Entering-air temperature in deg F.
   e. Leaving-air temperature in deg F.
   f. Voltage at each connection.
   g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and speed.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches.
   g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan speed.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
   a. System fan and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft..
   g. Indicated airflow rate in cfm.
   h. Indicated velocity in fpm.
   i. Actual airflow rate in cfm.
   j. Actual average velocity in fpm.
   k. Barometric pressure in psig.

K. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.16 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.

B. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.17 ADDITIONAL TESTS

A. Within [**90**] days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

SECTION 23 07 13

DUCT INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulation for HVAC ductwork.

B. Related Requirements:

1. Section 23 07 16 "HVAC Equipment Insulation."
2. Section 23 07 19 "HVAC Piping Insulation."
3. Section 23 31 13 "Metal Ducts" for duct liners.

1.02 DESCRIPTION

A. Provide all insulating materials and accessories as specified or as required for a complete installation.

B. Install all insulation in accordance with the latest edition of MICA (Midwest Insulation Contractors Association) Standard and manufacturer's installation instructions. Exceptions to these standards will only be accepted where specifically modified in these specifications.

1.03 DEFINITIONS

A. Concealed: shafts, furred spaces, space above finished ceilings, utility tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

1.04 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 elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.
5. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.05 QUALITY ASSURANCE

A. Refer to division 1, General Conditions, Equals and Substitutions.

B. Label all insulating products delivered to the construction site with the manufacturer's name and description of materials.

C. Insulation systems shall be applied by experienced contractors. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of at least 50% of the size and similar scope of the work specified in this section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Do not store insulation materials on grade or where they are at risk of becoming wet. Do not install insulation products that have been exposed to water.

C. Protect installed insulation work with plastic sheeting to prevent water damage.

D. Protect insulation material against long exposure to UV light from the sun.

1.07 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

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

1.08 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.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Armacell, CertainTeed, Manson, Childers, Dow, Extol, Fibrex, Halstead, Foster, Imcoa, Johns Manville, Knauf, Owens-Corning, Pittsburgh Corning, VentureTape or approved equal.

2.02 PERFORMANCE REQUIREMENTS

A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities

having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

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

2.03 INSULATION MATERIALS

A. Comply with requirements in “Ductwork Insulation Schedule" articles for where insulating materials are applied.

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

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Flexible closed-cell; Comply with ASTM C534/C534M, Type II for sheet materials.

1. Minimum nominal density of 5.5 lbs. per cu. ft., thermal conductivity of not more than 0.27 at 75 degrees F, minimum compressive strength of 4.5 psi at 25% deformation, maximum water vapor permeability of 0.17 perm inch, maximum water absorption of 6% by weight suitable for maximum use temperature between minus 20 deg F and 220 deg F on piping and minus 20 deg F and 180 deg F on equipment.

G. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; Comply with ASTM C553, Type II, and ASTM C1290.

1. Minimum nominal density of 0.75 lbs. per cu. ft., and thermal conductivity of not more than 0.30 at 75 degrees F, rated for service to 250 degrees F.

H. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; Comply with ASTM C612, Type IA or Type IB.

1. Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F, 0.25 at 125 degrees F, 0.27 at 150 degrees F, 0.29 at 200 degrees F, 0.32 at 250 degrees F, minimum compressive strength of 25 PSF at 10% deformation, rated for service to 450 degrees F.

2.04 ADHESIVES

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

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

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

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

E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.05 MASTICS AND COATINGS

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

B. Mastics and coatings shall be as recommended by insulation manufacturer for specified application.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Color: White.

2.06 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.
4. Coating to be anti-fungal with 0 growth rating.

2.07 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

2.08 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. FSJ Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.09 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.

B. FSJ Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.10 TAPES

A. FSJ Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

2.11 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; minimum 24 gauge with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed 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.

C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.01 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.

3.02 PREPARATION

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

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Where ductwork is specified to be pressure tested, do not insulate duct until pressure test has been successfully completed.

B. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards. Do not install products when the ambient temperature or conditions are not consistent with the manufacturer's recommendations.

C. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

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

E. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

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

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

H. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.

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

J. Install insulation with least number of joints practical.

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

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

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

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

O. Provide a continuous unbroken moisture vapor barrier on all insulated ductwork. 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.

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

Q. Where ductwork exposed to the weather is insulated, the top surface of the insulation shall be sloped a minimum of ¼" per foot to eliminate ponding and create positive drainage off of insulation. Refer to fluid-applied ductwork insulation section below for slope requirements.

3.04 PENETRATIONS

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

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

B. Insulation Installation at 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.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 07 84 00 " Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 00 "Firestopping."

3.05 GENERAL DUCT INSULATION INSTALLATION

A. Secure flexible duct insulation on sides and bottom of ductwork over 24" wide and all rigid duct insulation with weld pins. Space fasteners 18” on center or less as required to prevent sagging.

B. Secure rigid board insulation to ductwork with weld pins. Apply insulation with joints firmly butted as close as possible to the equipment surface. Pins shall be located a maximum of 3” from each edge and spaced no greater than 12” on center.

C. Install weld pins without damage to the interior galvanized surface of the duct. Clip pins back to washer and cover penetrations with tape of same material as jacket. Firmly butt seams and joints and cover with 4” tape of same material as jacket. Seal tape with plastic applicator and secure with staples. All joints, seams, edges and penetrations to be fully vapor sealed with vapor retarding mastic.

D. Stop and point insulation around access doors and damper operators to allow operation without disturbing insulation or jacket material.

E. For ductwork surfaces insulated with rigid fiberglass insulation, apply 2 coats of vapor barrier mastic after application of the insulating cement. Vapor barrier and weatherproof mastics to be applied with glass fiber reinforcing fabric.

F. Joints and seams of jackets for rigid fiberglass insulation shall be firmly butted together and covered with 6" wide glass cloth set in mastic. After first coat of mastic is dry, apply a second coat.

G. Where insulated ductwork is supported by trapeze hangers, the insulation shall be installed continuous through the hangers. Drop the supporting channels required to facilitate the installation of the insulation. Where rigid board or flexible insulation is specified, install high density inserts to prevent the weight of the ductwork from crushing the insulation.

H. Where insulated low temperature (below 45ºF) ductwork is supported by steel metal straps or wire ropes that are secured directly to the duct, the straps or ropes shall be completely covered with insulation and sealed to provide a complete vapor retarding barrier.

I. Where insulated duct risers are supported by steel channels secured directly to the duct, extend the insulation and vapor retarding jacketing to encapsulate the support channels.

J. On exterior ducts use mechanical fasteners for insulation. Provide overlapping insulation joints on exterior applications. Seal joints, breaks, and penetrations of vapor barrier facing with a vapor barrier tape as recommended by jacket manufacturer. Apply two coats of weatherproof mastic covering over the duct insulation with a glass fabric jacket between the two coats. Mastic surface shall have a smooth outside finish.

3.06 FIELD-APPLIED JACKET INSTALLATION

A. Where FSJ jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch 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.

3.07 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Strictly adhere to manufacturer's installation instructions and rating requirements for application of fire-stop insulation.

B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

C. Insulate duct access panels and doors to achieve same fire rating as duct.

D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 84 00 "Firestopping."

3.08 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

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.

C. Do not field paint aluminum or stainless steel jackets.

3.09 DUCT INSULATION SCHEDULE, GENERAL

A. Minimum installed R-Value is shown. Provide insulation conductivity and thickness comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.10 DUCT INSULATION SCHEDULE

A. Provide insulation on new ductwork as indicated in the following schedule:

SERVICE	INSULATION TYPE	JACKET	R-VALUE

Outside air ducts	Glass Fiber Board	FSJ	R-8
Mixed air ducts	Glass Fiber Board	FSJ	R-8
Relief air ducts	Glass Fiber Board	FSJ	R-8
Exposed supply ducts*	Glass Fiber Board	FSJ	R-6
Concealed supply ducts	Glass Fiber Blanket	FSJ	R-6
All Ducts located in uncon-ditioned Attics**	Glass Fiber Blanket	FSJ	R-12
Exhaust and relief ducts downstream of motorized backdraft dampers	Glass Fiber Board	FSJ	R-8
Exhaust ducts downstream of heat recovery units	Glass Fiber Board	FSJ	R-8
Exhaust ducts (Lower Level Parking)	Elastomeric	None	R-8

*Exposed supply branch ducts located in the space they are serving do not require insulation. Exposed supply main ducts running through spaces they serve shall be insulated as exposed supply ducts scheduled above.

** Outside air ductwork between the isolation damper and the outside air intake does not require insulation where it is located in an unheated attic.

END OF SECTION 23 07 13

SECTION 23 07 16

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulating HVAC equipment that is not factory insulated.

B. Related Sections:

1. Section 23 07 13 "Duct Insulation."
2. Section 23 07 19 "HVAC Piping Insulation."

1.02 DESCRIPTION

A. Provide all insulating materials and accessories as specified or as required for a complete installation.

B. Install all insulation in accordance with the latest edition of MICA (Midwest Insulation Contractors Association) Standard and manufacturer's installation instructions. Exceptions to these standards will only be accepted where specifically modified in these specifications.

1.03 DEFINITIONS

A. Concealed: shafts, furred spaces, space above finished ceilings, utility tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

1.04 SUBMITTALS

A. Product Data: For each type of product. 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 removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.
5. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.05 QUALITY ASSURANCE

A. Refer to division 1, General Conditions, Equals and Substitutions.

B. Label all insulating products delivered to the construction site with the manufacturer's name and description of materials.

C. Insulation systems shall be applied by experienced contractors. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of at least 50% of the size and similar scope of the work specified in this section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

B. Do not store insulation materials on grade or where they are at risk of becoming wet. Do not install insulation products that have been exposed to water.

C. Protect installed insulation work with plastic sheeting to prevent water damage.

D. Protect insulation material against long exposure to UV light from the sun.

1.07 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

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

1.08 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.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Armacell, CertainTeed, Manson, Childers, Dow, Extol, Fibrex, Halstead, Foster, Imcoa, Johns Manville, Knauf, Owens-Corning, Pittsburgh Corning, VentureTape or approved equal.

2.02 PERFORMANCE REQUIREMENTS

A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation located Outdoors: Flame-spread index up to 75, and smoke-developed index up to 150 when tested in accordance with UL 723 and ASTM E84.
3. Insulation applied to stainless steel shall meet requirements of ASMT C795 and NRC 1.36.

2.03 INSULATION MATERIALS

A. Comply with requirements in “Equipment Insulation Schedule" articles for where insulating materials are applied.

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

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate: Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

1. Minimum dry density: 12.5 lbs. per cu. ft., thermal conductivity of not more than 0.44 at 300 degrees F, maximum water absorption of 90% by volume, minimum compressive strength 140 psi at 5% deformation, rated for service range of 0 degrees F to 1,200 degrees F.
2. Material to be visually coded or marked to indicate it is asbestos free.
3. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.04 ADHESIVES

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

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

2.05 MASTICS AND COATINGS

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

B. Mastics and coatings shall be as recommended by insulation manufacturer for specified application.

C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.

1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
2. Service Temperature Range: Minus 50 to plus 220 deg F.

3. Color: White.

2.06 LAGGING ADHESIVES

A. Adhesives comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.07 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.
3. Color: White or gray.

C. Metal Jacket Flashing Sealants:

a. Foster 95-44 Elastolar
b. Childers CP-76 Chil-Byl
c. Pittsburgh Corning 727

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.08 FIELD-APPLIED JACKETS

A. Metal Jacket (PMJ):

1. Stainless Steel Jacket: ASTM A240/A240M.
   a. Sheet and roll stock ready for shop or field sizing.
   b. Thickness: 0.010 inch for indoor applications and 0.016 inch for outdoor applications, with safety edge.
   c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      1)

2.09 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; minimum 24 gauge with wing seal or closed seal.

2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; minimum 0.106-inch- diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; minimum 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel or Stainless steel, fully annealed, 0.106-inch- diameter shank; length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
   b. Spindle: Nylon, 0.106-inch- diameter shank; length to suit depth of insulation indicated, up to 2-1/2 inches.
   c. Adhesive: Recommended by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel or Stainless steel, fully annealed; 0.106-inch- diameter shank; length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel or stainless steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.10 CORNER ANGLES

A. Stainless Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.01 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 and equipment 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.

3.02 PREPARATION

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

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Where equipment is specified to be pressure tested, do not insulate equipment until pressure test has been successfully completed.

B. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards. Do not install products when the ambient temperature or conditions are not consistent with the manufacturer's recommendations.

C. Do not insulate equipment that is factory insulated.

D. Do not insulate over equipment nameplates or ASME stamps. Bevel and seal insulation at these locations.

E. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

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

G. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

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

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

J. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents, unless otherwise approved by the engineer-of-record.

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

L. Install insulation with least number of joints practical.

M. Cut insulation in a manner to avoid compressing insulation.

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. Where a vapor barrier is required, apply 2 coats of vapor barrier mastic after application of the insulating cement.

Q. 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 attached 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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

R. Where a vapor barrier is not required, apply 2 coats of weatherproof mastic after application of the insulating cement.

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

T. Cut insulation in a manner to avoid compressing insulation.

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

V. 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 in similar fashion to butt joints.

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

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

3.04 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:

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

3.05 FIELD-APPLIED JACKET INSTALLATION

A. 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 o.c. and at end joints.

3.06 FINISHES

A. Do not field paint aluminum or stainless steel jackets.

3.07 EQUIPMENT INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable 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 is Contractor's option.

3.08 EQUIPMENT INSULATION SCHEDULE

EQUIPMENT	INSULATION TYPE	JACKET	THICKNESS
Generator exhaust pipe and muffler	Calcium Silicate/ Fire-proofing	PMJ***	3"

1 **END OF SECTION 23 07 16**

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SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulation for HVAC piping systems.

B. Related Requirements:

1. Section 23 07 13 "Duct Insulation" for duct insulation.
2. Section 23 07 16 "HVAC Equipment Insulation" for equipment insulation.
3. Section 23 23 00 “Refrigerant Piping”.

1.02 DESCRIPTION

A. Provide all insulating materials and accessories as specified or as required for a complete installation.

B. Install all insulation in accordance with the latest edition of MICA (Midwest Insulation Contractors Association) Standard and manufacturer's installation instructions. Exceptions to these standards will only be accepted where specifically modified in these specifications.

1.03 DEFINITIONS

A. Concealed: shafts, furred spaces, space above finished ceilings, utility tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

1.04 SUBMITTALS

A. Product Data: For each type of product. 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 attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.05 QUALITY ASSURANCE

A. Refer to division 1, General Conditions, Equals and Substitutions.

B. Label all insulating products delivered to the construction site with the manufacturer's name and description of materials.

C. Insulation systems shall be applied by experienced contractors. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of at least 50% of the size and similar scope of the work specified in this section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

B. Do not store insulation materials on grade or where they are at risk of becoming wet. Do not install insulation products that have been exposed to water.

C. Protect installed insulation work with plastic sheeting to prevent water damage.

D. Protect insulation material against long exposure to UV light from the sun.

1.07 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "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.

C. Coordinate installation and testing of heat tracing.

1.08 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.

PART 2 - PRODUCTS

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

1. Armacell, CertainTeed, Manson, Childers, Dow, Extol, Fibrex, Halstead, Foster, Imcoa, Johns Manville, Knauf, Owens-Corning, Pittsburgh Corning, VentureTape or approved equal.

2.02 PERFORMANCE REQUIREMENTS

A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation located Outdoors: Flame-spread index up to 75, and smoke-developed index up to 150 when tested in accordance with UL 723 and ASTM E84.
3. Pipe insulation which is not located in an air plenum may have a flame spread rating not over 25 and a smoke developed rating no higher than 450 when tested in accordance with UL 723 and ASTM E84.
4. Insulation applied to stainless steel shall meet requirements of ASMT C795 and NRC 1.36.

2.03 INSULATION MATERIALS

A. Comply with requirements in “Piping Insulation Schedule" articles for where insulating materials are applied.

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

C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin.

1. Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F, 0.25 at 125 degrees F, 0.27 at 150 degrees F, 0.29 at 200 degrees F, 0.32 at 250 degrees F, minimum compressive strength of 25 PSF at 10% deformation, suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C547.
2. Preformed Pipe Insulation: Type I, Grade A.
3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

2.04 INSULATING CEMENTS

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

B. Insulating cements shall be as recommended by insulation manufacturer for specified application.

C. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.

D. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.

E. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.05 ADHESIVES

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

B. Adhesives shall be as recommended by insulation manufacturer for specified application.

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

D. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
2. Wet Flash Point: Below 0 deg F.
3. Service Temperature Range: 40 to 200 deg F.
4. Color: Black.

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

F. SJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.06 MASTICS AND COATINGS

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

B. Mastics and coatings shall be as recommended by insulation manufacturer for specified application.

C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.

1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.07 LAGGING ADHESIVES

A. Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.
4. Coating to be anti-fungal with 0 growth rating.

2.08 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Permanently flexible, elastomeric sealant.
   a. Service Temperature Range: Minus 150 to plus 250 deg F.
   b. Color: White or gray.

C. FSJ and Metal Jacket Flashing Sealants:

1. Manufacturers:
   a. Foster 95-44 Elastolar
   b. Childers CP-76 Chil-Byl
   c. Pittsburgh Corning 727
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:

1. Fire- and water-resistant, flexible, elastomeric sealant.
2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. Color: White.

2.09 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 C1136, Type I. Maximum permeance of 0.02 perms and minimum beach puncture resistance of 50 units.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, Type I for use over insulation on pipes conveying fluid below 65 deg F and Type II for use over insulation on pipes conveying fluid above 65 deg F, or where a vapor retarder is not required.

B. PVC Jacket (PFJ): High-impact-resistant, UV-resistant PVC complying with ASTM D1784, FS LP-535D, Composition A, Type II, Grade GU; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.

2. Thickness:
   a. Piping 12” and smaller: 0.02 inch indoors, 0.03 inch outdoors
   b. Piping greater than 15”: 0.03 inch indoors, 0.04 inch outdoors.
3. Color: White, gloss finish one side, semi-gloss other side.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket (PMJ):

1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Factory cut and rolled to size.
   b. Thickness: 0.016 inch for indoor applications and 0.024 inch for outdoor applications, with safety edge.
   c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed two-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. Stainless Steel Jacket: ASTM A240/A240M.
   a. Factory cut and rolled to size.
   b. Thickness: 0.010 inch for indoor applications and 0.016 inch for outdoor applications, with safety edge.
   c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed two-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.

D. Self-Adhesive Indoor/Outdoor Jacket (SAJ): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive.

Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

1. Minimum thickness: 6 mils.
2. Puncture resistance: 25 lb in accordance with ASTM D1000
3. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
4. Flamespread/Smoke Developed: 10/20 in accordance with UL 723.
5. Aluminum Finish: Smooth.

E. Vapor Retarding Jacket (VRJ)

1. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.
2. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.
3. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.11 INSULATION INSERTS AND PIPE SHIELDS

A. Manufacturers: B-Line, Pipe Shields, Value Engineered Products.

B. Construct inserts with calcium silicate or polyisocyanurate (service temperatures below 300 degrees F only), minimum 140 psi compressive strength. Piping 12” and larger, supplement with high density 600 psi structural calcium silicate insert.

C. Provide galvanized steel shield.

1. Insert and shield to be minimum 180 degree coverage on bottom supported piping and full 360 degree coverage on clamped piping. On roller mounted piping and piping designed to slide on support, provide additional load distribution steel plate.

D. Where contractor proposes shop/site fabricated inserts and shields, submit schedule of materials, thicknesses, gauges and lengths for each pipe size to demonstrate equivalency to pre-engineered/premanufactured product described above.

1. On low temperature systems, high density rigid polyisocyanurate may be substituted for calcium silicate provided insert and shield length and shield gauge are increased to compensate for lower insulation compressive strength.

E. Precompressed 20# density molded fiberglass blocks, Hamfab or equal, of the same thickness as adjacent insulation may be substituted for calcium silicate inserts with one 1”x6” block for piping through 2-1/2” and three 1”x6” blocks for piping through 4”. Submit shield schedule to demonstrate equivalency to pre-engineered/premanufactured product described above.

F. Wood blocks will not be accepted.

2.12 EXPANSION JOINT AND VALVE INSULATION BLANKETS

A. Manufacturers: Advance Thermal Corporation, TANI Division B.D. Schiffler, or approved equal. Site fabricated blankets are not acceptable.

B. Blanket shall be 17 ounce per square yard PTFE coated fiberglass fabric which is designed for wet and dry steam applications to 550ºF. Equal to Advance Thermal Corp. Steamguard-2. Jacket shall have PTFE coated fabric on both exterior and interior. Wire mesh interior is not acceptable.

C. The Blankets shall be installed to shed water and have a 3-inch wide cinchable rain flap on each end.

D. All seams shall be sewn twice with double locked stitching. One seam shall be sewn with 3-ply Nomex and the other with 3-ply stainless steel. Hog rings and staples shall not be used.

E. The insulation shall be a 2-inch thick, compressed “E” glass fiber with no chemical binders, held in place with 12 gauge stainless quilt pins which do not puncture the inner surface of the blanket.

F. Blankets shall be designed to allow access to the expansion and ball joints packing cylinder plungers for repacking without removing the blanket.

G. Removable expansion joint blanket shall be constructed to allow the pipe and rigid insulation to expand/contract with the pipe. Blanket shall have a close fit without sagging or gaps.

H. Blanket shall allow for normal operation of the valve or joint without removing the cover.

I. Valve blankets shall come in two pieces and cover the valve yoke (if applicable).

J. Blankets shall have D-ring, hook and loop or buckle securing straps. Pins and wire or spring and ring securement is not acceptable.

K. Blankets shall have a stainless steel identifying plaque on the exterior identifying equipment information.

2.13 FIELD-APPLIED FABRIC REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

2.14 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 6 oz./sq. yd..

2.15 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

B. FSJ Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

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

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

2.16 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; minimum 24 gauge with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.01 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.

3.02 PREPARATION

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

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards. Do not install products when the ambient temperature or conditions are not consistent with the manufacturer's recommendations.

B. 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.

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

D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

E. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.

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

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

H. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents, unless otherwise approved by the engineer of record.

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

J. Install insulation with least number of joints practical.

K. Provide a continuous unbroken moisture vapor retarding jacket on insulation applied to systems noted below. Attachments to cold surfaces shall be insulated and vapor sealed to prevent condensation. Provide a complete vapor retarding jacket for insulation on the following systems:

1. Refrigerant
2. Insulated Duct
3. Equipment, ductwork or piping with a surface temperature below 65 degrees F

L. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic. Vapor barrier shall be continuous and unbroken.

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 attached to structure with vapor-barrier mastic.
3. Install insert materials and 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.

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

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

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
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 2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.
4. For below-ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

O. Cut insulation in a manner to avoid compressing insulation.

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

Q. 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 in similar fashion to butt joints.

R. 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.

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

1. Hot water piping inside radiation, convector, or cabinet heater enclosures
2. Steam Traps
3. Piping unions for systems not requiring a vapor retarding Jacket

T. For systems with fluid temperatures 65° F or less, furnish and install removable elastomeric insulation covers, plugs or caps for all mechanical equipment and devices that require access by balancing contractors or service and maintenance personnel. Covers shall be tight fitting to ensure a complete vapor retarding barrier. Examples include but are not limited to:

1. Flow sensing devices, circuit setters, manual ball valve air vents, drain valves, blowdown valves, pressure/temperature test plugs, grease fittings, pump bearing caps, equipment labels, etc.

3.04 PENETRATIONS

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

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

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

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

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

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

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

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.05 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 below.

B. Install insulation with butt joints and longitudinal seams closed tightly. Provide minimum 2” lap on jacket seams and 2” tape on butt joints, firmly cemented with lap adhesive unless otherwise noted. Additionally secure with staples along seams and butt joints.

C. On systems requiring a vapor retarding jacket, seal off all raw ends of insulation and butt joints with vapor retarding mastic at intervals of not more than 20 feet on piping. Coat staples, longitudinal and transverse seams with vapor retarding mastic and on systems requiring vapor retarding jacket, coat insulated elbows, fittings, and valves with vapor retarding mastic.

D. Install insulation continuous through pipe hangers and supports with hangers and supports on the exterior of insulation. Where a vapor retarding jacket is not required or where roller hangers are not being used, hangers and supports may be attached directly to piping with insulation completely covering hanger or support and jacket sealed at support rod penetration. Where riser clamps are required to be attached directly to piping requiring vapor retarding jacket, extend insulation and vapor retarding jacketing/coating around riser clamp.

E. Where insulated piping is installed on hangers and supports, the insulation shall be installed continuous through the hangers and supports. High density inserts shall be provided as required to prevent the weight of the piping from crushing the insulation. Pipe shields are required at all support locations. The insulation shall not be notched or cut to accommodate the supporting channels.

F. Insulation Inserts and Pipe Shields:

1. Provide pipe shields at all hanger and support locations. Rigid insulation inserts shall be installed between the pipe and the insulation shields. Quantity and placement of inserts shall be according to the manufacturer's installation instructions, however the inserts shall be no less than 12" in length. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required for system.
2. Provide insulation inserts and pipe shields at all hanger and support locations. Inserts may be omitted on 3/4" and smaller copper piping provided 12" long 22 gauge pipe shields are used.

G. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Fittings, valves, unions, flanges, couplings and specialties may be insulated with factory molded or built up insulation of the same thickness as adjoining insulation. Where the ambient temperature exceeds 150 degrees F, cover insulation with fabric reinforcing and mastic. Where the ambient temperatures do not exceed 150 degrees, furnish and install PVC fitting covers.

H. 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.

I. Mineral Fiber:

1. Secure each 3' section with three metal bands snip off excess and turn ends over into insulation to prevent exposed sharp edges. Stagger joints where more than one layer is used.

J. Elastomeric and Polyolefin:

1. Where practical, slip insulation on piping during pipe installation when pipe ends are open. Miter cut fittings allowing sufficient length to prevent stretching. Completely seal seams and joints for vapor tight installation.

2. For elastomeric insulation, apply full bed of adhesive to both surfaces.
3. For polyeolefin, seal factory preglued seams with roller and field seams and joints with full bed of hot melt polyolefin glue to both surfaces.
4. Cover elastomeric insulation on systems operating below 40 degrees F with vapor retarding mastic.

K. Extruded Polystyrene and Polyisocyanurate:

1. Fittings, valves, unions, flanges, couplings and specialties shall be insulated with factory molded insulation of the same thickness as adjoining insulation.
2. Secure insulation sections with two wraps of nylon filament tape 9”-12” on center.
3. On single insulation layer systems and on the outer layer of double insulation layer systems, apply a thin coat of elastomeric joint sealant rated for system operating temperatures to all longitudinal and butt insulation joints covering entire face of joint. Allow sealant to fully cure before applying protective covering.
4. For piping service below 0oF, use two layers of insulation with inner and outer butt and longitudinal joints staggered and offset 90 degrees. Where two layers of insulation are used, do not use sealant on the inner layer or adhere the inner layer to the outer layer.
5. Apply vapor stop bead of joint sealant between pipe and insulation on both sides of valves, expansion/contraction joints, flanges, thermometers/gauges, attached vent and drain lines. Insulate attached non-circulated lines, control lines, vents, etc. for a minimum distance of 6” from pipe.
6. Cover insulation with a protective jacket as specified below. Do not penetrate protective covering or insulation with mechanical fasteners.

3.06 INSTALLATION OF PROTECTIVE JACKETS

A. In addition to the jackets specified in the pipe insulation schedule below the following protective jackets are required:

B. Provide a protective PVC jacket (PFJ) for the following insulated piping:

1. Piping exposed in finished locations
2. All piping within mechanical rooms.

C. Provide a protective metal (PMJ) or self-adhering (SAJ) jacket for the following insulated piping:

1. Exterior installed refrigeration piping.

D. ALL SERVICE JACKETS (ASJ) and FOIL SCRIM ALL SERVICE JACKETS (FSJ):

1. Install according to manufacturer’s recommendations using factory supplied lap seals and butt strip seals.

E. PROTECTIVE METAL JACKET (PMJ):

1. Lap seams a minimum of 2 inches. Secure with metal bands for end to end joints, and rivets or sheet metal screws for longitudinal joints. Rivets, screws, and bands to be constructed of the same material as the jacket.
2. Locate seams on bottom for exterior applications.
3. Seal laps with 1/8” bead of metal jacketing sealant to prevent water entry.

F. SELF-ADHERING JACKETS (SAJ):

1. Install according to manufacturer's recommendations. Cut allowing minimum 4" overlap on ends and 6" on longitudinal joints. Align parallel to surface. Remove release paper and press flat to surface to avoid wrinkles. Rub entire surface for full adhesion and sealing at joint overlaps. On exterior applications, provide a bead of compatible caulk along exposed edges.
2. Piping with self-adhering (SAJ) jackets shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. Piping with a PVC jacket (PFJ) installed over the self-adhering (SAJ) jacket may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket.
3. Vapor retarding tape shall be compatible with the jacket material used.

G. VAPOR RETARDING JACKETS (VRJ):

1. Piping with vapor retarding jackets (VRJ) shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. Piping with a PVC jacket (PFJ) installed over the vapor retarding jackets (VRJ) may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket.
2. Vapor retarding tape shall be compatible with the jacket material used.

3.07 REMOVABLE INSULATION BLANKETS

A. Install removable insulation covers on expansion slip joints, ball joints, and valves 2-1/2" and larger.

B. Install blankets to be field removable without tools.

C. Blankets shall be installed to allow the normal expansion and contraction associated with these systems, without crushing or damaging the blanket.

D. Expansion Joint blankets shall extend over the adjacent rigid insulation to allow for pipe expansion.

E. Blankets shall be installed without sagging or gaps.

F. Blankets shall be installed to shed water.

G. Steam system will not be allowed to turn on until removable jackets are installed.

H. Installation conforms 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 that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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.

3.08 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."

1. Flat Acrylic Finish: [**Two**] <**Insert number**> finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

D. Do not field paint aluminum or stainless steel jackets.

3.09 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. 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.

3.10 PIPING INSULATION SCHEDULE

A. Provide insulation on new piping as indicated in the following schedule. Provide jacketing as schedule unless specified otherwise herein.

SERVICE	INSULATION	JACKET	INSULATION THICKNESS BY PIPE SIZE				
			< 1”	1” to < 1-1/2”	1-1/2” to < 4”	4” to < 8”	8” and Larger
Refrigerant Suction, Liquid	Glass-Fiber	ASJ	1”	1.5”	1.5”	1.5”	1.5”
Cooling Coil Condensate Drain	Glass-Fiber	VRJ or SAJ	0.5”	0.5”	1”	1”	1”

END OF SECTION 23 07 19

SECTION 23 09 02

CONTROL VALVES AND DAMPERS

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 09 23 – Direct Digital Control (DDC) for HVAC.

B. Section 23 33 00 – Air Duct Accessories

1.02 GENERAL

A. Devices containing mercury are not allowed.

1.03 SUBMITTALS

A. Product data sheets shall include construction materials and assembly methods, maximum design parameters (temperature, pressure, velocity, etc.), and performance data for full range of actuator stroke. Product data sheets shall include charts, graphics or similar items used in making selections, including damper to duct area ratio and free area ratio. Damper product data sheets shall indicate certified leakage rates for given pressure differentials.

B. Submit valve schedules with shop drawings, indicating unique tag numbers for each device, equipment item or system served, device model numbers, sizes, shut-off head required, actuator air pressure or force required to meet shut-off head, torque requirements for rotary valves, flow coefficients (Cv) for 10% and 100% valve stem travel, actual flow requirements based on equipment shop drawings, calculation of actual pressure drops, actuator model number, actuator torque capacities and pilot positioner locations.

C. Valve and damper Shop Drawing submittals will not be processed unless supporting data and sizing calculations are included.

D. Submit damper schedules with Shop Drawings, indicating unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, pressure differentials, calculation of actual damper pressure drops, approach velocities, leakage rates, torque requirements, actuator model number, actuator torque capacities and pilot positioner locations.

E. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential. Damper materials shall match duct construction materials of systems in which they are installed (galvanized steel, aluminum, 304 or 316 stainless steel, etc.).

F. Aluminum dampers may be used in galvanized steel ductwork.

1.04 DAMPER SELECTION AND SIZING

A. Submit engineering calculations for sizing modulating control dampers including outside, return, and relief air dampers of air handling units unless dampers are scheduled.

B. Calculations for sizing dampers shall be based on actual characteristics of ductwork system being installed. Opposed blade dampers shall be sized for minimum of 10% of duct system pressure drop. Parallel blade dampers shall be sized for minimum of 30% of duct system pressure drop. Duct section is defined as ductwork containing flow control damper starting with inlet or branch tee and ending with outlet or branch tee. Calculate actual duct pressure drops for each duct section containing modulating damper using latest version of ASHRAE Handbook of Fundamentals. If control systems fixes pressure drop, use those pressure setpoints. Use balance damper to provide additional pressure drop as required for obtaining linear damper response.

C. Control Contractor is responsible for obtaining adequate system information necessary for sizing.

D. Two position dampers to be sized as close as possible to duct size, but in no case is damper size to be less than duct area.

E. Submit leakage and flow characteristic data for control dampers along with shop drawings. Leakage ratings shall be based on AMCA Standard 500 and dampers shall bear AMCA Air Leakage Seals.

PART 2 - PRODUCTS

2.01 CONTROL DAMPERS

A. General

1. If control damper sizes are not shown or scheduled, refer to Part 1 of this section criteria unless otherwise indicated, modulating control damper shall be opposed. Blade or parallel blade type and 2- position (open/Close) dampers shall be parallel blade type.
2. Blade linkage hardware shall have corrosion-resistant finish and be readily accessible for maintenance.
3. AMCA Leakage Classification of Control Dampers

Class	**Static Pressure** Inches Water Column			
	1	4	8	12
	Leakage Rate cfm/ft^2			
IA	3	N/A	N/A	N/A
I	4	8	11	14
II	10	20	28	35
III	40	80	112	140

B. Standard Modulating and Two-Position Dampers:

1. Manufacturers and acceptable model numbers:
   a. Johnson Controls VD-1360 (Double Piece)
   b. Honeywell D2
   c. Ruskin CD50/CD60
   d. Air Balance AC-525/526
   e. Greenheck VCD-43/VCD-33
2. Damper frames shall be minimum of 16 ga galvanized steel or 14 ga extruded aluminum. Blades shall be minimum of 16 ga galvanized steel or 14 ga aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.

3. Furnish dampers with blade seals and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -40° to 200°F, pressure differential of 6" WC, and approach velocity of 4000 fpm based on 4 ft damper section width.
4. Leakage rate shall meet AMCA Leakage Class IA or I.
5. Testing and ratings shall be per AMCA Standard 500-D.

2.02 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties, for Smoke Damper Specification.

2.03 DAMPER AND VALVE ACTUATORS

A. Analog Electronic:

1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or TAC
2. Actuators shall be electric motor/gear drives that respond proportionally to analog voltage or current input, or digital floating control signals.
   a. Floating control actuators shall only be used for terminal hot water or chilled water control.
   b. Analog control actuators shall be used for all other modulating applications.
3. Stroke time for major equipment shall be 90 seconds or less for 90° rotation. Stroke time for terminal equipment shall be compatible with associated local controller, but no more than 6 minutes.
4. Provide spring return feature for fail open or closed positions, as required by control sequence, for critical applications such as outside, return, or exhaust dampers, heating and cooling coils on major air handling units, humidifiers, heat exchangers, flow control for major equipment items such as chillers, cooling towers, boilers, etc. Fail-last-position actuators do not have spring return feature.
5. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops.
6. Actuators for terminal heating/cooling equipment do not require spring return feature.

B. Discrete Two-Position Electric:

1. Manufacturers: Belimo, Honeywell, Johnson Controls, Siemens Building Technologies or TAC
2. Actuators shall be electric motor/gear drives for two-position control. Stroke time shall be 90 seconds or less for 90° rotation.
3. Provide spring return feature for fail open or closed positions as required by control sequence. Fail-last-position actuators do not have spring return feature.

C. Speed Control Valve:

1. Manufacturers: ASCO, Parker Hannifin or approved alternate
2. Provide speed control valves for On/Off actuators to limit speed of actuation to prevent water hammers in liquid systems and reduce stresses on large dampers in air systems.
3. Speed control valves shall allow free flow of control air in one direction and metered flow in other direction. Valve stem locks shall be included to lock adjustment knob in place.
4. Mount speed control valve to exhaust port of solenoid control valve or impulse line from solenoid control valve to actuator, depending upon whether speed control is required for closing or opening of valve or damper.

5. Materials of Construction: Brass bodies with Buna-N, NBR or Nitrile Seals

PART 3 - EXECUTION

3.01 CONTROL DAMPERS

A. Furnish control dampers as shown on drawings and/or as required to perform control sequences specified, except those furnished with other equipment.

B. Control dampers furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.

C. Blank-off plates or transitions required to facilitate dampers shall be provided by Mechanical Contractor.

3.02 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties

3.03 ACTUATORS AND PILOT POSITIONERS

A. Provide actuator for each automatic damper or valve with sufficient capacity to operate damper or valve under all conditions. Select actuators to provide tight shut-off against maximum system temperatures and pressure encountered. Each actuator shall be full-modulating or two-position type as required or specified, and shall be provided with spring-return for fail open or fail closed position for fire, freeze, moisture, occupant safety, equipment protection, heating or cooling system protection on power interruption as indicated and/or as required. Smoke dampers and steam valves serving pressure rated heat exchangers or convertors shall fail-closed.

B. Valve and damper operating speeds shall be selected or adjusted so that actuators will remain in step with controllers without hunting, regardless of load variations. Actuators acting in sequence with other actuators shall have adjustment of control sequence as required by operating characteristics of system.

C. Provide proper linkage and brackets for mounting and attaching actuators to devices. Design mounting and/or support to provide no more than 5% hysteresis in either direction (actual movement of valve stem or damper shaft versus ideal movement) due to deflection of actuator mounting.

D. Provide single actuator on damper section not exceeding torque capacity of actuator.

E. Multiple damper sections where used shall be connected together via jackshaft or other coupling device, not by internal pinned connections at blade shafts of individual damper sections. Where multiple damper sections are connected together via jackshaft or other coupling device, damper actuator shall be mounted directly to jackshaft or other coupling device for operating damper sections. For instances where damper actuator cannot be mounted to jackshaft or other coupling device, damper actuator shall be provided for each damper section.

1. Mounting multiple actuators to common damper jackshaft or valve stem to meet torque requirements is not allowed.

F. Position feedback potentiometers shall be provided where floating control actuators are sequenced with other floating control actuators in terminal hot water control (i.e., reheat valve, fin tube radiator valve, radiant ceiling panel valve, etc.).

G. Calibrate position feedback potentiometers, where specified, with range and gain factors as required for proper operation per manufacturer's recommendations.

H. Actuators installed outdoors shall be NEMA 4X or IP66 rated or shall be provided with weatherproof NEMA 4X stainless steel enclosures (Belimo ZS-300 or equal) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork.

END OF SECTION 23 09 02

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SECTION 23 09 03

CONTROL INSTRUMENTATION

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 09 23 – Direct Digital Control (DDC) for HVAC.

B. Section 23 09 05 - Instrument Point List

C. Section 23 09 93 - Control Sequences

1.02 SUBMITTALS

A. Devices shall be indexed by bill of material for each system as detailed in Section 23 0901 - Control Systems Integration.

B. Device data sheets submittal shall be submitted simultaneously with Control Systems Integration submittal. Refer to submittals section in 23 0901.

C. Thermostat/Room Temperature Sensor Schedules:

1. Submit thermostat/room temperature sensor schedule with shop drawings. Thermostat/room temperature sensor schedule shall have detailed listing of which type is used for each room, including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.

D. Warranty

1. Provide 1 year warranty on all materials and labor.
2. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 year warranty period.

1.03 FCC COMPLIANCE

A. Digital equipment furnished under this Contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled.

PART 2 - PRODUCTS

2.01 GENERAL

A. Instruments of same type shall be by same manufacturer, for instance, pressure transmitters, gauge, absolute, and differential pressure shall be of same manufacturer.

B. Pressure and temperature ratings of devices indicated in Part 2 - of this Section are minimum required. Devices shall be designed to withstand maximum pressures and temperatures encountered in respective systems.

C. No devices containing mercury will be allowed under this Specification.

2.02 GENERAL INSTRUMENTATION

A. Pressure Gauges:

1. Refer to Section 23 2120 - Piping Specialties

B. Thermometers (Dial-Type):

1. Refer to Section 23 2120 - Piping Specialties

C. Analog Electronic Instrument Indicators:

1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output may be either analog needle type or digital with 1/2" high LED or backlit LCD displays.
2. Electronic indicators shall be marked in appropriate units (degrees, psi, % rh, gpm, cfm, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

2.03 DISCRETE ELECTRIC INSTRUMENTATION

A. General:

1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units (garage parking area is considered outside) shall be NEMA 4 with concealed adjustment.
2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
3. Accuracy of devices shall be ± 1% of scale with adjustable offset unless otherwise specified.

B. Temperature Switches (Electric Thermostats):

1. Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.
2. Low voltage type to have heat anticipation.
3. Thermostats with remote sensing bulb shall have liquid filled sensing element and exposed setpoint adjustment.
4. Wall mounted space thermostat enclosure shall have concealed sensing element and exposed setpoint adjustment.
5. Unless otherwise stated, space thermostat covers shall be manufacturer’s standard plastic.

C. Relays

1. Manufacturers: IDEC, Potter Brumfield, Square D, or Allen Bradley
2. Equal to IDEC Type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 10A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.

D. Enclosed Relay (Relay in Box):

1. Manufacturers: Veris Industries, Kele & Associates, Functional devices, Inc. or approved equal
2. 1 or 2 SPDT relays in NEMA 1 or better enclosure. Coil shall be selected for control circuit characteristics.
3. Contacts rated at 10A, 28 VDC or 120 VAC. Conduit nipple is 1/2" NPT. Maximum coil current burden 50 milliamps.

E. Pressure Differential Switches (Air Systems):

1. Manufacturers: Cleveland Controls, Dwyer, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, or TAC
2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
3. Pressure differential switches for air systems shall have pressure rating of at least 10" WC.
4. Switches used to protect installed system shall be manual reset type with two single pole double through contacts (SPDT)
5. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
   a. Maximum Temperature Rating: 180°F
   b. Repeatability: ± 1%

F. Current Switches – Constant load, Constant Speed:

1. Manufacturers: Veris Industries, N-K Technologies, Absolute Process Instruments, Kele & Associates, R-K Electronics or approved equal
2. These shall be Induction type sensors clamped over single phase conductor of AC electrical power and shall be solid-state sensors with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.
   a. Output: Solid state relay or relay contacts
   b. Trip Setpoint: Adjustable by multi-turn potentiometer
   c. Operating Temperature: 32 to 131°F
   d. Response Time: < 0.5 seconds

G. Current Switches - Variable Load, Variable Speed

1. Manufacturers: Veris Industries, N-K Technologies or approved equal
2. These shall be induction type sensors clamped over single-phase conductor of AC electrical power and shall consist of solid-state sensors with self-calibrating threshold and normally open Contacts.
   a. Output: Solid state relay or relay contacts
   b. Trip Setpoint: Adjustable by multi-turn potentiometer
   c. Operating Temperature: 32 to 131°F
   d. Response Time: < 0.5 seconds

H. Mechanical Room and Local Control Panel Alarm Horns:

1. Manufacturers: Honeywell, Johnson Controls, Siemens, Panalarm, TAC, or Ronan
2. 24 V alarm horn suitable for panel mounting.

I. Plant Alarm Horns:

1. Manufacturers: Panalarm, Johnson Controls/Penn, Honeywell, Siemens Building Technologies, or Sonalert
2. Equal to Honeywell model SC806A rated at 64-100 dBa at 10 ft, 24 VAC operation. UL Listed and FM approved

J. Indicator Lights:

1. Manufacturers: Allen Bradley, GE, Square-D, or Idec
2. 1/4" minimum size or 1-1/4" maximum size, push-to-test type. Use green for normal, yellow for warning (low/high values), and red for alarm or fail (low-low or high-high conditions). AC or DC type with voltage matched to control circuit without transformers.

K. Drain Pan Moisture Detector:

1. Manufacturers: Kele and Associates, DiversiTech or approved alternate.
2. Moisture detector is small, electronic control relay for detecting rising water levels, within drain pans or other containments. Moisture detector shall alarm when water levels reach 0.43” to prevent damage from overflow of drain pans. Relay shall reset when water levels decrease to 0.31” and relay re-energizes.
3. Relay is normally energized upon powering up and no water is present. When water level reaches the trip point the relay de-energizes for alarming in BAS.
4. Moisture Detector Relay Module (Model LD1-24):
   a. Supply Voltage: 24 VAC, 60 Hz
   b. Power Consumption: 1 W
   c. Cable length: 18-inches
   d. Relays Contacts:
      1) Type: SPDT
      2) Rating: 2.5A at 24 VDC; 5.0A at 120 VAC
   e. Enclosure Rating: Hermetically Sealed
   f. Dimensions: 0.87” H x 2.0” W x 1.25” L

2.04 PNEUMATIC INSTRUMENTATION

A. Space Static Pressure Sensor:

1. Manufacturers: Air Monitor Corporation, Tek-Air or Thermo Electron Corporation
2. Space static pressure probe shall be brushed aluminum with anodized finish or stainless steel with polished or painted finish selected by Architect.
3. Shielded static air probe shall be similar to Air Monitor Corporation Model 3 for flush ceiling mounting, complete with multiple sensing ports, pressure impulse suppression chamber, air flow shielding, and 3/8" FPT take-off fitting. Sensor shall be capable of sensing static pressure within 1% of actual pressure value while being subjected to maximum air flow of 100 fpm from radial source.

B. Differential Air Pressure Indicator:

1. Dwyer model 2000 Series magnehelic gauge for surface or panel mounting. 4" dial readout, die cast aluminum housing. Case and aluminum parts Iridite-dipped. Exterior finish to be baked dark grey hammerloid. Hi/lo 1/8" pressure taps. Provide adapters to match tubing type.
   a. Accuracy: ± 2% of full scale.
   b. Ambient Temperature Range: 20 to 140°F
   c. Rated Total Pressure: -20" Hg to 15 psig
   d. Range: 0-2 times normal setpoint. (Use 0-0.25" WC for building and space pressure indication.)

C. Plastic Tubing:

1. 1. Fire resistant virgin polyethylene, meeting stress-crack test ASTM D1693. Individual tube polyethylene or multi-tube instrument tubing bundle shall be classified as flame retardant under UL94. Polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM 9 D635. 94. Polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM 9 D635.

2.05 ANALOG ELECTRONIC INSTRUMENTATION

A. Gas Detection Systems:

1. Manufacturers: Toxalert, Dräeger, Enmet, Honeywell Analytical, MSA or approved alternate
2. Provide gas detectors as listed below. Each detector shall be complete package with remote or local space sensors, detection instruments, local indication of current measured value for each sensor and status indicator lights for power and status of each sensor. Devices not requiring remote mounting shall be housed in metal control panel. Status indicators shall be mounted on panel faceplate.
3. Units shall have adjustable setpoints and self-test diagnostics.
   a. Gas to be Detected CO and NO2
   b. Alarm Setpoint:
      1) CO: low level control signal alarms 15 PPM, 25 PPM, 35 PPM and high alarm 100 PPM
      2) NO2: low alarm 1 PPM, high alarm 3 PPM
   c. Range:
      1) CO: 0-2 times Alarm Setpoint
      2) NO2: 0-10 ppm NO2
   d. Remote Sensor: As required.
   e. Signal: 4-20 mA; Below 4 mA indicates sensor failure
   f. Housing: NEMA 4X
   g. Temperature: -10°F to 110°F
   h. Locations: See floor plans.

B. Space Temperature Sensors:

1. 1. Sensors shall be platinum RTD type, with the following minimum performance:
   a. Temperature Coefficient of Resistivity (TCR): 0.00385 ohm/ohm/□C
   b. Accuracy: ± .54°F + (0.005 X T) (Class B)
   c. Accuracy: ± .27°F + (0.005 X T) (Class A)
      T = Temperature of interest
   d. Conformance: DIN-IEC 751
   e. Operating Range: 32 to 122°F, 0 to 99% rh

2. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of ± 0.36°F between 32°F and 150°F, and 0.5°F between 41 -20°F and 212°F.
3. Unless otherwise stated, space sensor cover shall be manufacturer's standard plastic cover.

C. Duct Mounted or Insertion Temperature Sensors:

1. Platinum RTD type, with the following minimum performance:
   a. Temperature Coefficient: 0.00385 ohm/ohm/°C
   b. Accuracy: ± .54°F + (0.005 X T) (Class B)
   c. Accuracy: ± .27°F + (0.005 X T) (Class A)
      T = Temperature of interest
   d. Conformance: DIN-IEC 751
   e. Operating Range:-50 to 170°F, 0 to 99% RH
2. Install insertions sensors in stainless steel probes or wells.
3. Outside air sensors shall be weatherproof of noncorrosive construction and protected with solar shield. Mount outside air sensors on north side of building or in area intake wells for air handling systems to avoid thermal effects from direct sunlight.
4. Sensors mounted in air streams, such as air handling units, supply ducts, exhaust ducts or return ducts, shall be averaging type. Averaging type sensor to be installed in ducts larger than 24" x 24" or greater than 576in2. Mount averaging sensor across duct area in a "Z" pattern using mounting clips specific for averaging temperature sensor probes.
5. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that the device will maintain its accuracy within a tolerance of ± 0.36°F between 32°F and 150°F, and 0.5°F between -20°F and 212°F.

D. Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:

1. Manufacturers: GE Modus, Setra, Ashcroft XLDP or approved equal
2. Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
3. Unit shall be capable of transmitting linear 4 - 20 mA DC output signal proportional to differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
   a. Span: Not greater than twice duct static or velocity pressure at maximum flow rate, or more than 16 times velocity pressure at minimum flow rate.
   b. Accuracy: ± 1.0% of span or ± 1.0% of full scale
   c. Dead Band: Less than 0.5% of output
   d. Hysteresis: Within 0.5% of span or within 0.5% of full scale
   e. Linearity: Within 1.0% of span or within 0.5% of full scale
   f. Repeatability: Within 0.5% of output
   g. Response: Less than 1 second for full span input
4. Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from static pressure sensing stations and with static air probes to prevent migration of moisture and particulate matter into transducers. If inputs to pressure transducers/transmitters are dead-ended, integral air filters are not required. Supply air system sensors do not require integral air filters.

E. Differential Pressure Flow Element: Pitot Tube

1. Manufacturers: Dieterich Standard, Preso, Veris Inc. or approved alternate

2. These shall be averaging differential pressure type flow elements. Flow element shall consist of:
   a. Sensing tube with two internal chambers. One shall sense upstream pressure and one shall sense downstream pressure.
   b. These chambers shall have ports of quantity and size to accurately sense flowrate in piping line-size into which these are specified to be installed.
   c. Sensing tube shall have form so shaped as to minimize measurement inaccuracies.
   d. Sensing assemblies shall be provided with suitable supports to prevent damage to these assemblies at maximum flow-rate.
      1) Accuracy: Error ± 1.0% of sensor rated range
      2) Repeatability: Error ± 0.5%
      3) Sensor Materials of Construction: Stainless Steel unless otherwise noted
   e. Insert/Retract "Hot Tap" including insertion device and isolation valve:
      1) Each sensor, which is required to be Hot-Tap shall be provided with isolating valve, packing gland and retraction tube assembly.
      2) Each sensor that is specified to be installed into line in which pressure is greater than 200 psig, or for acid or caustic service, or for hazardous chemical service shall be provided with retaining hardware to allow mechanical retraction and insertion.
   f. Refer to Section 23 2120 - Piping Specialties for Flow Sensors, provided for balancing purposes
   e.

F. Rotary (Damper) Position Sensors:

1. Manufacturers: Kele & Associates, Fisher Controls or Westlock
2. Provide position 4-20 mA transmitter with potentiometer type (variable resistance) sensor for damper position measurement. Measurement to be linear to damper stroke.
   a. Performance:
      1) Power Supply: 24 VDC unregulated
      2) Accuracy: ± 1% of output span
      3) Repeatability: ± 0.5% of full span
      4) Maximum Temperature: 125°F

G. P-E Transducers (Pressure Transmitters):

1. Manufacturers: Ashcroft, Mamac, Setra, Kele & Associates or GE Modus
2. Units shall have the following characteristics:
   a. Input:Pressure 0-15 psig, minimum
   b. Output Signal: 4-20 mA, 0-5 VDC, 1-5 VDC, 1-10 VDC
   c. Accuracy: 1% of span
   d. Operating Temperature 32 to 125°F
   e. Power Requirements: 24 VDC (10-30 VDC)

PART 3 - EXECUTION

3.01 GENERAL

A. A. Install control equipment and wiring in neat and workmanlike manner and in accordance with manufacturer's Recommendations. Maintain clearances, straight length distances, etc., required for proper operation of each device. Mark and detail on coordination drawings, exact locations of inline devices, wells, and taps to be installed by Mechanical Contractor.

B. Coordinate timely delivery of materials and supervise activities of other trade Contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. Mount motor control devices within 5 ft of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor and flow meter locations with Owner and Engineer for approval prior to installation.

3.02 GENERAL INSTRUMENTATION

A. Local Control Panels:

1. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc., inside of local control panels.
2. Locate panels as shown on drawings.
3. Locate panels adjacent to equipment served with minimum of 3 ft clearance in front of door. Provide sufficient clearances to allow full door swing and full access to internal components. Submit proposed panel locations with shop drawing submittals.
4. Mount top of panels between 5 and 6 ft above floor so that gauges and indicators are at eye level.

3.03 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Thermostats/Temperature Sensors:

1. Install space thermostats/sensors where indicated, as required to perform specified control sequences, and as directed to meet job site conditions.
2. Provide space temperature sensors without remote setpoint adjustment in all public spaces, hallways, and mechanical rooms unless otherwise specified.
   a. Mount space thermostats/sensors at 5 ft above floor unless otherwise indicated.
   b. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 4 ft above floor meeting ADA requirements.
3. Space thermostats/sensors located on exterior walls shall be mounted on thermally insulated sub- base.
4. Relocate space thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
5. Mount space thermostats/sensors in corridors, stairways and public toilets 7 ft above floor. Space thermostats/sensors in corridor, stairways, vestibules and toilets shall be aspirating type. Space thermostats/sensors shall be protected by heavy-duty cast and die formed guard.

B. RTD Temperature Transmitters:

1. Provide RTD temperature transmitters whenever DDCPs cannot receive RTD type inputs.

C. C. Static Pressure and Air Flow Stations:

1. Furnish static pressure and air flow measuring stations to Mechanical Contractor for installation.
2. Stations shall be installed in strict accordance with manufacturer's published requirements. These stations serve as primary signals for airflow control systems; therefore it shall be responsibility of Control Contractor to verify location and installation to assure that accurate primary signals are obtained.
3. Pressure differential switches shall be piped across device creating differential between fan discharge and fan suction.

D. D. Outside Air Temperature Sensors:

1. Mount on north side of building or in intake area wells for air handling systems. Provide solar shields for installations where sensors may be exposed to sunlight conditions.

E. E. Transmitters, Indicators, and Transducers:

1. Locate transmitters at sensing devices or within 100 ft of remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount. For indicating type instruments, locate indicating element within 6 ft of floor with readout easily visible from floor level. Provide remote readouts if necessary.
2. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

3.04 PNEUMATIC PIPING

A. Conceal all piping, except for piping in mechanical rooms and other areas where mechanical system piping is exposed.

B. Install exposed piping and conduit parallel to or at right angles to building structure and support adequately at uniform intervals.

1. Provide tubing clamps with insulated standoffs where metallic tubing may come into contact with other dissimilar metals to prevent galvanic corrosion from occurring. Use of wire ties or hose clamps to fasten tubing to structure or other piping is not allowed.
2. Use of tubing channel designed for mounting polyethylene tubing shall be allowed.

C. Polyethylene tubing not exceeding 18" exposed may be used for connection to instrument or actuator.

D. Install polyethylene tubing with no concealed splices and number code all tubing.

E. Piping type shall be as follows:

1. Inside Panels:
   a. Use polyethylene tubing.
2. Exposed:
   a. Polyethylene tubing may be used if run in fully enclosed rigid metal raceway or metal conduit where environment is within temperature limits of polyethylene tubing. Use PVC coated copper tubing or stainless steel tubing for wet environments.
3. Concealed:
   a. Use polyethylene tubing.

END OF SECTION 23 09 03

SECTION 23 09 05

INSTRUMENT POINT LIST

PART 1 - GENERAL

1.01 RELATED WORK

A. Section 23 09 23 – Direct Digital Control (DDC) for HVAC.

B. Section 23 09 02 – Control Valves and Dampers

C. Section 23 09 03 – Control Instrumentation

D. Section 23 09 93 – Control Sequences

1.02 SUBMITTALS

A. Point List:

1. Submittals shall include list of each control input and output, device it is controlling, locations of device, and symbol or label of control point in software.
2. The points listed on the attached “Instrument Point List” are not all inclusive. In addition to the points listed, include those points required to implement and monitor the features described in the control sequences.

1.03 INSTRUMENT OR DEVICES USED FOR POINT INPUT TO BAS

A. Control Contractor shall be responsible for providing necessary point input to BAS for equipment and systems provided by Mechanical Contractor or Control Contractor not covered in sequences of operation but necessary for operation of those systems or equipment.

B. Instrument or devices such as auxiliary contacts of equipment provided by other than Mechanical Contractor or Control Contractor, will be furnished with the equipment unless otherwise indicated.

1.04 ANALOG ALARM POINTS

A. Unless indicated in Section 23 0993, consult Owner for the specific values to be used for High and Low limit alarms during programming.

PART 2 - PRODUCTS

2.01 Not applicable to this Section.

PART 3 - EXECUTION

3.01 Not applicable to this Section

END OF SECTION 23 09 05

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SECTION 23 09 23

DIRECT DIGITAL CONTROL (DDC) FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. Provide new standalone FMCS for this project with connection to city server system.

1.02 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years' experience.
B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.
C. Technician: Minimum five years' experience installing commercial temperature control systems.
D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 100 miles of the job site.

1.03 SUBMITTALS

A. Equipment Coordination:
   1. The Controls Contractor shall obtain approved equipment submittals from other contractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.
   2. Control valve selections shall be based on flow rates shown in approved shop drawings.
   3. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.
B. Shop Drawings:
   1. Submit shop drawings per Division 01. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to the Owner for review.
   2. Cross-reference all control components and point names in a single table located at the beginning of the submittal with the identical nomenclature used in this section.
   3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.
   4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.
   5. Diagrams shall include:
      a. Wiring diagrams and layouts for each control panel showing all termination numbers.
      b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
      c. Identification of all control components connected to emergency power.
      d. Schematic diagrams for all field sensors and controllers.
      e. A schematic diagram of each controlled system. The schematics shall have all control

points labeled. The schematics shall graphically show the location of all control elements in the system.

f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.
g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.
h. All installation details and any other details required to demonstrate that the system will function properly.
i. All interface requirements with other systems.

6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.

Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.

7. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.

8. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:
   a. Damper Identification Tag.
   b. Location.
   c. Damper Type.
   d. Damper Size.
   e. Duct Size.
   f. Arrangement.
   g. Blade Type.
   h. Velocity.
   i. Pressure Drop.
   j. Fail Position.
   k. Actuator Identification Tag.
   l. Actuator Type.
   m. Mounting.

9. Valve Schedule: Valve manufacturer shall size valves and create a valve schedule. Schedule shall include a separate line for each valve and a column for each of the valve attributes:
   a. Valve Identification Tag.
   b. Location.
   c. Valve Type.
   d. Valve Size.
   e. Pipe Size.
   f. Configuration.
   g. Flow Characteristics.
   h. Capacity.
   i. Valve CV.
   j. Design Pressure Drop.

k. Pressure Drop at Design Flow.
l. Fail Position.
m. Close-off Pressure.
n. Valve and Actuator Model Number and Type.

10. Airflow Measuring Station Schedule:
    a. The manufacturer's authorized representative shall prepare the airflow measuring station submittal, or review and approve in writing the submittal prepared by the TCC prior to submission to the Architect/Engineer and prior to installation. The representative shall review air handling equipment submittals and duct fabrication drawings to ensure that all AFMS locations meet the appropriate parameters to achieve proper installation and the specified accuracy. Comply with all manufacturer's installation requirements including straight up and downstream duct lengths. Install airflow straighteners if required by the manufacturer based on installation constraints. The Architect/Engineer shall be notified for approval of any deviations.
    b. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
    c. Submit installation, operation, and maintenance documentation.
11. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.
12. Provide PICS files indicating the BACnet® functionality and configuration of each device.
13. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements in the event that problems are found during BTL testing is required.
14. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation.
15. Software: A list of operating system software, operator interface software, color graphic software, and third-party software.
16. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.
17. Clearly identify work by others in the submittal.
18. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

C. Operation and Maintenance Manual:
1. In addition to the requirements of Section 23 05 00, submit an electronic copy of the O&M manuals in PDF format.
2. Provide three complete sets of manuals.
3. Each O&M manual shall include:
    a. Table of contents with indexed tabs dividing information as outlined below.
    b. Definitions: List of all abbreviations and technical terms with definitions.
    c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of contractors installing equipment and controls and service representatives of each.
    d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.
    e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor
    f. Operating Procedures: Include procedures for operating the control systems;

logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.

g. Programming: Description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.

h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.

i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.

k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project.

D. Training Manual:

1. Provide a course outline and training manuals for each training class.

E. Record Documents:

1. Submit record documentation per Division 01.
2. Provide a complete set of “as-built” drawings and application software on CDs. Provide drawings as AutoCAD™ or Visio™ compatible files. Provide two copies of the “as-built” drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.
3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.
4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.
5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the A/E verifying completion and proper operation of all points.

1.04 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather

B. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.05 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Valves.
B. Flow Switches.
C. Temperature Sensor Sockets.
D. Gauge Taps.
E. Automatic Dampers.
F. Flow Meters.

1.06 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.

1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 “Signal Equipment.”
3. EMC Directive 89/336/EEC (European CE Mark)
4. FCC, Part 15, Subpart J, Class A Computing Devices

1.07 ACRONYMS

A. Acronyms used in this specification are as follows:

B-AAC	BACnet Advanced Application Controller
B-ASC	BACnet Application Specific Controller
BTL	BACnet Testing Laboratories
DDC	Direct Digital Controls
FMCS	Facility Management and Control System
GUI	Graphic User Interface
IBC	Interoperable BACnet Controller
IDC	Interoperable Digital Controller
LAN	Local Area Network
NAC	Network Area Controller
ODBC	Open Database Connectivity
OOT	Object Oriented Technology
OPC	Open Connectivity via Open Standards
PICS	Product Interoperability Compliance Statement
PMI	Power Measurement Interface
POT	Portable Operator’s Terminal
TCC	Temperature Control Contractor
TCS	Temperature Control System
WAN	Wide Area Network

1.08 SUMMARY

A. Provide new standalone FMCS for this project with connection to city server system.

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.

D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

1.09 SYSTEM DESCRIPTION

A. A. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

B. The FMCS shall include Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner’s local or wide area network, depending on configuration. Provide

access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

C. Provide materials and labor necessary to connect factory supplied control components.

D. Provide central and remote hardware, software, and interconnecting wire and conduit.

E. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

F. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

1.10 SOFTWARE LICENSE AGREEMENT

A. A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide the Owner with all required IDs and passwords for access to any component or software program. The Owner shall determine which organizations shall be named in the SI organization ID (“orgid”) of all software licenses. Owner shall be free to direct the modification of the “orgid” in any software license, regardless of supplier.

1.11 JOB CONDITIONS

A. A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.12 WARRANTY

A. A. Refer to Section 23 05 00 for warranty requirements.

B. B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on the Owner’s archived software disks.

1.13 WARRANTY ACCESS

A. A. The Owner shall grant to this Contractor reasonable access to the TCS and FMCS during the warranty period.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

3

Acceptable Manufacturers	BACnet Protocol
Honeywell WEBs-ControlWorks	●

2.02 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, printers, network devices, valves, dampers, sensors, and other devices as specified herein.
2. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.
3. The FMCS shall be based on Tridium's Niagara Framework and adhere to the open NICS licensing. The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The system shall support JACE Version 3.8. The JACE shall connect to the local area network, depending on configuration. 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 JACE is capable communicate to LonMark/LonTalk (ILC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.
4. The FMCS shall be based on the NiagaraAX Framework (or "NiagaraAX"), a Java-based framework developed by Tridium. NiagaraAX provides an open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the NiagaraAX Framework platform are unacceptable.
5. The entire Temperature Control System (TCS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating via LonMark/LonTalk and/or BACnet communication protocols to Java Application Control Engines (JACE) which communicate BACnet TCP/ IP or OBIX TCP/IP to the Niagara AX Server. Niagara AX Supervisor Software to be installed on owner provided server.
6. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). All Niagara AX software licenses shall have the "accept.station.in=*" and "accept.station.out=*"and "accept.wb.in=*" and "accept.wb.out=*" section of the software licenses. The intent is to insure that the installed Niagara AX products may be completely open for integrations. Owner shall be free to direct the modification of any software license, regardless of supplier. In addition, the owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with Niagara Framework (Niagara AX) based controllers and/or servers and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required I.D.'s and passwords for access to any component or software program shall be provided to the owner. Provide all software necessary for developing software algorithms in all supervisory, programmable and application specific direct digital controllers which is licensed to the Owner.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true “peer-to-peer” communicating devices. Components or controllers requiring “polling” by a host to pass data are not acceptable.
2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.
3. Hierarchical or “flat” topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer’s internal intranet network.
    a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
    b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.03 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:
    1. Ethernet; IEEE Standard 802.3.
    2. Cable; 100 Base-T, UTP-8 wire, Category 6.
    3. Minimum throughput; 100 Mbps.

C. C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and “safed” off in an appropriate manner.

E. There shall be no power wiring in excess of 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer’s wiring practices.

2.04 REMOTE NETWORK ACCESS

A. For Local Area Network installations, provide access to the LAN from a remote location via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer’s intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.05 NETWORK AREA CONTROLLER (NAC)

A. The TCC shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 23 and 26. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:
   1. Calendar functions.
   2. Scheduling.
   3. Trending.
   4. Alarm monitoring and routing.
   5. Time synchronization.
   6. Integration of all controller data.
   7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:
   1. One Ethernet Port – 10/100 Mbps.
   2. One RS-232 port.
   3. One LonWorks Interface Port – 78KB FTT-10A (for LonWorks systems only).
   4. One RS-485 port.
   5. Battery backup.
   6. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
   7. The NAC must be capable of operation over a temperature range of 32°F to 122°F.
   8. The NAC must be capable of withstanding storage temperatures of between 0°F and 158°F.
   9. The NAC must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the NAC shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:
   1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
   2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.
   3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:
      a. Alarm
      b. Normal
   4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.
   5. Provide timed (scheduled) routing of alarms by class, object, group, or node.
   6. Provide alarm generation from binary object “runtime” and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:
   1. Screen message text.

2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e- mail alarms based on:
   a. Day of week.
   b. Time of day.
   c. Recipient.
3. Pagers via paging services that initiate a page on receipt of e-mail message.
4. Graphic with flashing alarm object(s).
5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:
1. Time and date.
2. Location (building, floor, zone, office number, etc.).
3. Equipment tag.
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a “query” feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.06 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):
1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system’s compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.
2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:
   a. BACnet Building Controller(s) (B-BC).
   b. BACnet Advanced Application Controller(s) (B-ACC).
   c. BACnet Application Specific Controller(s) (B-ASC).
3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which

the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.

5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.
6. The Contractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:
   a. BACnet Device; MAC address, name, type and instance number.
   b. BACnet Objects; name, type and instance number.
7. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries

1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.
4. All control objects shall conform to the control objects specified in the BACnet specification.
5. The library shall include applications or objects for the following functions, at a minimum:
   a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.
   b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
   c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.
   d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.
   e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined

interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user's screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand- limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:
   a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
   b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.
   c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
   d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.
   e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.
   f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
   g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
   h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.

i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.

j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an “on” state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.

k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the “contained” application that are represented on the graphic shell of this container.

7. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). Provide the following as part of the standard library included with the programming software:

a. LonMark/LonWorks Devices: These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer- specific objects to facilitate simple integration of these devices. Support all network variables defined in the LonMark profile. The device manufacturer shall provide information (type and function) regarding network variables not defined in the LonMark profile.

b. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file, and documentation for the device to facilitate device integration.

c. For BACnet devices, provide the following objects:

1) Analog In.
2) Analog Out.
3) Analog Value.
4) Binary.
5) Binary In.
6) Binary Out.
7) Binary Value.
8) Multi-State In.
9) Multi-State Out.
10) Multi-State Value.
11) Schedule Export.
12) Calendar Export.
13) Trend Export.
14) Device.

d. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.
e. For BACnet devices, provide the following support at a minimum:
   1) Segmentation.
   2) Segmented Request.
   3) Segmented Response.
   4) Application Services.
   5) Read Property.
   6) Read Property Multiple.
   7) Write Property.
   8) Write Property Multiple.
   9) Confirmed Event Notification.
   10) Unconfirmed Event Notification.
   11) Acknowledge Alarm.
   12) Get Alarm Summary.
   13) Who-has.
   14) I-have.
   15) Who-is.
   16) I-am.
   17) Subscribe COV.
   18) Confirmed COV notification.
   19) Unconfirmed COV notification.
   20) Media Types.
   21) Ethernet.
   22) BACnet IP Annex J.
   23) MSTP.
   24) BACnet Broadcast Management Device (BBMD) function.
   25) Routing.

2.07 TERMINAL AIR BOX (TAB) CONTROLLERS

A. FMCS Volume Controller: Electronic, furnished and installed by TCC. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. Provide velocity and static sensor at box inlet for use by unit controller. Set boxes for maximum and minimum settings shown on the drawings. Refer to Section 23 36 00 for additional information.
B. The controller shall support various digital and analog inputs and outputs as needed for damper control, control valves, electric coils, airflow sensors, remote heating, occupancy sensors, etc. and shall be capable of independent occupancy scheduling.
C. Controller shall provide continuous zone temperature histories internal to device for up to 24 hours and perform its own limit and status monitoring and alarms to limit unnecessary communications.
D. Operator interface to any ASC point data or programs shall be through network resident programs or portable.
E. Operator's terminal connected to the specific controller.
F. Store all system setpoints, proportional bands, control algorithms, and other programmable parameters such that a power failure of any duration does not necessitate reprogramming of the controller.
G. BACnet TAB controllers shall either be B-AAC devices or B-ASC devices as required to meet the performance and BTL listing.

2.08 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. The NAC shall be able to collect data for any property of any object and store resident in the NAC that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.
2. For interval logs, configure the object for time of day, day of week and the sample collection interval.
3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.
5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

B. Store all log data in a relational database in the NAC that is accessible from a server (if the system is so configured) or a standard Web browser.

C. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

D. All log data shall be available to the user in ALL the following data formats:
1. HTML.
2. XML.
3. Plain text.
4. Comma or tab separated values.

E. The NAC shall archive its log data either locally (to itself) or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties:
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.

2.09 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user- defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
1. Time and date.
2. User ID.
3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.10 DATABASE BACKUP AND STORAGE

A. The NAC shall automatically backup its database on a user-defined time interval.

B. Store copies of the current database and, at the most, the recently saved database in the NAC. The age of the most recently saved database shall depend on the user-defined database save interval.

C. Store the NAC database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.11 GRAPHIC USER INTERFACE SOFTWARE

A. Operating System:
1. Provide computer with the most current Microsoft-based operating system with which the GUI has proven compatibility.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu pulldowns and toolbars shall employ buttons, commands and

navigation to permit the operator to perform tasks with basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line) that displays the location and the selected object identification.

C. Point Organization: Organize points by equipment categories, location, or other means acceptable to Owner.

D. Real-Time Displays: The GUI shall support the following graphic features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file. Use of proprietary graphic file formats is not acceptable. In addition to, or in lieu of, a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall be able to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
3. Graphics shall support layering, and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
4. Modifying common application objects, such as schedules, calendars, and setpoints, shall be accomplished graphically.
   a. Schedule times shall be adjusted using a graphic slider without requiring any keyboard entry from the operator.
   b. Holidays shall be set by using a graphic calendar without requiring any keyboard entry from the operator.
5. Commands to start and stop binary objects shall be made by selecting the object and the appropriate command from a pop-up menu. No text entry shall be required.
6. Adjustments to analog objects, such as setpoints, shall be made by selecting the object and using a graphic slider to adjust the value. No text entry shall be required.

E. System Configuration: At a minimum, the GUI shall include the necessary software and components to enable the operator to perform the following tasks with proper password access:

1. Create, delete or modify control strategies.
2. Add/delete objects.
3. Tune control loops by adjusting control loop parameters.
4. Enable or disable control strategies.
5. Generate hard copy records or control strategies on a printer.
6. Select alarm points and define the alarm state.
7. Select points to be trended and initiate the recording of values automatically.
8. View any trend as a graph.

F. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

G. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall be able to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall be automatically logged off the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. Store all system security data in an encrypted format.

H. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. Annunciate the failure of any device to the operator.

I. Alarm Console:

1. The system shall have a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and to acknowledge the alarm.

2. When the alarm console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable. The use of the alarm console can be enabled or disabled by the system administrator.

2.12 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™, Firefox™, or Chrome. Systems requiring additional software to enable a standard Web browser to reside on the client machine, or manufacturer-specific browsers, are not acceptable.

B. 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 Graphic User Interface. Systems that require different views or that require different means of interacting with objects, such as schedules or logs, are not permitted.

C. The Web browser client shall provide:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, display a blank web page. Implement security using Java authentication and encryption techniques to prevent unauthorized access.
2. Graphic screens developed for the GUI shall be the same screens used for the Web browser client. The web browser interface shall support all animated graphic objects supported by the GUI.
3. 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.
4. Store all graphic screens in the Network Area Controller (NAC) without requiring any graphics storage on the client machine.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
6. 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 setpoints, graphically.
      1) Schedule times shall be adjustable using a graphic slider, without requiring any keyboard entry from the operator.
      2) Holidays shall be set using a graphic calendar, without requiring any keyboard entry from the operator.
   b. Commands to start and stop binary objects shall be made by right-clicking the selected object and selecting the appropriate command from a pop-up menu. No text entry shall be required.
   c. View logs and charts.
   d. View and acknowledge alarms.
   e. Setup and execute SQL queries on log and archive information
7. The system shall be able to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just his/her defined home page. From the home page, links to other views or pages in the system shall be possible, if allowed by the system administrator.
8. 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.

2.13 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. UPS shall be provided for all controllers including FMCS workstations and servers.

B. Provide a 120 volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for 5 minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on- battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.

C. Acceptable Manufacturers: Sola/Hevi-Duty, Eaton Powerware, APC.

2.14 OPERATOR'S WORKSTATION HARDWARE

A. Workstations shall communicate with BAS on as-needed basis such that other executionable programs may be processed without affecting control functions of BAS.

B. Provide operator's workstations for operating interface to BAS for monitoring, control, and database management. Each workstations shall consist of the following at a minimum:

1. Case and 250 watt power supply.
2. Motherboard with Pentium 17 microprocessor
3. BIOS in flash memory
4. Sufficient expansion slots to be properly configured for intended use
5. 8 GB RAM
6. 101 key, keyboard with 12 function keys
7. 17" color SVGA monitor with SVGA interface card with 128 MB video SDRAM
8. (3) USB ports and (2) Ethernet ports.
9. 48X max variable speed CD-ROM drive
10. 1 TB hard disk drive
11. Network interface card and associated hardware
12. All required cables for connecting to network and other remote devices
13. Mouse and mouse pad
14. Surge Protector and UPS
15. 8 page per minute letter size laser printer with direct network interface port.

2.15 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user, interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user's application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.

2. Configuration of each object shall be done through the object's property sheet using fill-in-the- blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.
5. The system shall support object duplication in a customer's database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.16 DDE DEVICE INTEGRATION

A. A. The NAC shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The NAC shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:
   1. DDE Generic AI Object.
   2. DDE Generic AO Object.
   3. DDE Generic BO Object.
   4. DDE Generic BI Object.

2.17 MODBUS SYSTEM INTEGRATION

A. The NAC shall support integration of device data from Modbus RTU, ASCII, and TCP control system devices. Connect to the Modbus system via an RS-232, RS485, or Ethernet IP as required by the device.

B. Provide the required objects in the library included with the GUI programming software to support the integration of the Modbus system data into the FMCS. Objects provided shall include, at a minimum:
   1. Read/Write Modbus AI Registers.
   2. Read/Write Modbus AO Registers.
   3. Read/Write Modbus BI Registers.
   4. Read/Write Modbus BO Registers.

C. The NAC shall perform all scheduling, alarming, logging and global supervisory control functions of the Modbus system devices.

D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment using Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.

2.18 2.18 SOFTWARE

A. A. IDC/IBCs shall operate totally standalone and independent of a central computer for all specified control applications.

B. Software shall include a complete operating system (OS), communications handler, point processing, energy management application packages as specified herein, standard control

algorithms and specific control sequences (IDC/IBC) and an Owner/user custom control calculation package complete with interpreter.

C. OS software shall be PROM resident, operate in real time, provide prioritized task scheduling, control time programs, monitor and manage communications, and scan inputs and outputs.

D. Each IDC/IBC panel shall include the following energy management routines:
   1. Time of day scheduling.
   2. Optimum start/stop.
   3. Peak demand limiting.
   4. Economizer control.
   5. PID control.
   6. Supply air reset.
   7. Outdoor air reset.

E. Input/output point processing software shall include:
   1. Update of all connected input and output points at least once per second.
   2. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32-bit floating point format. Retain both the maximum and minimum values sensed for each analog input in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full- scale 32- bit conversion to achieve high accuracy readout.
   3. A reasonability check on all analog inputs against previous values and discarding of values falling outside preprogrammed reasonability limits.
   4. Assignment of proper engineering units and status conditions to all inputs and outputs.
   5. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and alarm) to an input or to assign a set of floating limits (alarm a reset schedule or FMCS control point) to the input. Assign each alarm a unique differential to prevent a point from oscillating in and out of alarm. Make alarm comparisons of each scan cycle.
   6. Adjustment of timing from two seconds to two minutes in one-second increments to eliminate nuisance alarms on startup.

F. Command Control software shall manage the receipt of commands from the server and from control programs.
   1. Provide command delay to prevent simultaneous energizing of loads. Delay must be programmable from 0 to 30 seconds.
   2. Assign each command a command and residual priority to manage conflicts created by multiple programs having access to the same command point. Allow only outputs with a higher command priority to execute. Whenever a command is allowed to execute, its assigned residual priority shall replace the existing residual priority.
   3. A "fixed mode" option (override) shall allow inputs to and outputs from control programs to set to a fixed state or value. When in the "fixed mode", assign inputs and outputs high residual command priority to prevent override by application programs.

G. Alarm lockout software shall prevent nuisance alarms. On initial start-up of mechanical equipment, assign a "timed lockout" period to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period shall be programmable for each point from 0 to 90 minutes in one-minute increments.

H. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when a true alarm depends on the condition of an associated point. Hard lockout points and lockout initiators shall be operator programmable.

I. Runtime shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Runtime counts shall reside in non- volatile memory and have DCP resident runtime limits assignable through the operator's terminal.

J. A transition counter shall count the number of times a device is cycled on or off. Counter shall be non-volatile and capable of counting 600,000 cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.

K. Custom IDC/IBC programs shall meet the control strategies called for in the sequence of operation of these specifications. Each IDC/IBC shall have resident in its memory and available to the programs a full library of IDC/IBC algorithms, intrinsic control operators, arithmetic, logic, and relational operators. Provide the following features:

1. 1. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning). Use Adaptive Control where the controlled flow rate is variable (such as TAB units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that, on system shutdown and restart, the learning process starts from where it left off. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
2. All IDC/IBC setpoints, gains and time constants associated with IDC/IBC programs shall be available to the operator for display and modification via the operator workstation.
3. The execution interval of each IDC/IBC loop shall be adjustable from 2 to 120 seconds in one-second increments.
4. IDC/IBC control programs shall assign initialization values to all outputs so controlled devices assume a failsafe position on start-up.

L. L. Provide time and event programming (TEP) capability to initiate a controlled sequence of events for execution at a specific time or upon the occurrence of an event. Minimum program features required are:

1. Analog points commandable to a specific value.
2. Digital points commandable to a specific state; e.g. on or off; fast, slow or off.
3. Initiator to be a specific day and time or a specific event; e.g. an alarm.
4. Manual initiation via operator's command.
5. Commands must honor command delays (to prevent current surges), and assigned minimum ON and OFF times.
6. Commands must honor command and residual priority structures allowing higher priority commands (like smoke control) to override lower priority commands (like time of day scheduling) and residual priority.
7. Ability to chain TEPs.
8. Ability to enable and disable TEPs individually.
9. Ability to enable/disable TEP initiators.

M. Store Energy Management application programs and associated data files in non-volatile or 72-hour battery backed RAM memory. Individual programs shall be accessible from the operator workstation for enabling/disabling and program parameter modification and shall include:

1. Time Programs:
   a. Provide an independent start and stop program time for each system identified in the points list.
   b. It shall be possible to assign two independent start and stop times/days to any equipment connected to a controller.
2. Exception Day Scheduling:
   a. Provide an Exception Day program for holiday and other planned exceptions to time programs. Exception schedules shall be DSC resident and operator programmable up to one year in advance.
   b. The program shall allow definition of up to 32 exception time spans. Define each span by calendar start day and calendar stop day.

3. An IDC/IBC resident temporary scheduler shall allow operators to modify present time program control of equipment. Minimum feature set required is:
   a. Ability to alter time schedules as much as six days in advance.
   b. Ability to alter either start time, stop time or both for each day.
   c. Temporary schedule shall be in effect for all days specified.
   d. Automatically delete the temporary schedule and restore program to normal schedule after execution.
   e. Ability to assign schedule changes as permanent as well as temporary.

N. The IDC/IBC shall have built-in, non-descriptive, self-test procedure for checking the indication lights, digital display, and memory. It shall display advisories for maintenance, performance, and/or software problems.

O. All electronics shall be:
   1. Standard locally stocked modular boards.
   2. Plug-in type.
   3. Furnish all ROM programs unlocked.

2.19 ACTUATORS

A. A. Actuators for control dampers and valve actuators shall be electronic type

2.20 CONDUIT

A. A. Raceway and boxes for electrical systems: Refer to Electrical Section 26 05 33 for materials and sizing.

2.21 WIRE AND CABLE

A. A. Low-Voltage electrical power conductors: Refer to Electrical Section 26 05 19 for wire and cable materials.

2.22 2.22 LOCAL CONTROL PANELS

A. A. Local control panels shall be constructed of steel or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color. Construction shall comply with NEMA 1 Standards for interior panels, NEMA 4 for exterior panels and panels located in the parking structure.

B. Controlling instruments, temperature indicators, relays, switches and gauges shall be factory installed and permanently labeled. Devices shall be located inside or mounted on face of panel.

C. Unless otherwise indicated, mount control and adjusting switches, temperature indicators and other indicating or manually operated devices on front face of panel with black phenolic engraved nameplates.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed 48". In accordance with the requirements of LEED EQc1: Outdoor Air Delivery Monitoring, install all wall-mounted CO2 sensors between 3 feet and 6 feet above the floor.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

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.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units, pumps, or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall not be powered from the life safety branch of the emergency power system. Coordinate emergency power source connections with the Architect/Engineer.

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Labels For Control Devices:

1. Provide labels indicating service of all control devices in panels and other locations.
2. Labels may be made with permanent marking pen in the control panels if clearly legible.
3. Use engraved labels for items outside panel such as outside air thermostats.
4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

N. VFDs

1. This project includes several variable frequency drives to control the flow of fans and/or pumps based on a control variable.
2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.
3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.
4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.
5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

O. Airflow Stations:

1. The transmitter shall be installed at a location that is protected from weather, water, and vibration.
2. Mount transmitter where they can easily be read (36" to 66" above floor). Do not fasten transmitters directly to ductwork or compromise duct insulation.
3. The manufacturer's authorized representative shall visit the project site during construction prior to station installations to confirm all submitted sizes, mounting

requirements and locations. Size adjustments shall be made at no additional cost. The representative shall meet on site with the TCC to support and train them on proper installation procedures and calibration.

4. Install labels at each sensor and transmitter identifying its service.

3.02 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.
B. Components shall be arranged on graphic as installed in the field.
C. Include each graphic point listed in the itemized points list using real time data.
D. Provide a graphic representation of the following:
   1. Where there are multiple buildings, color code the campus map by the systems serving that building. The building graphic shall be linked to the graphic for that building's systems.
   2. Where there are multiple floors, provide color codes/designations for the areas served by each AHU and TAB by floor.
   3. Where multiple AHUs serve one floor, color code the areas served by each AHU. The area shall be linked to the graphic for that area's AHU.
   4. Provide an overall floor plan of each floor of the building color coded by zone linked to the TAB for that zone. The zone shall be linked to the graphic for that zone's TAB graphic.
   5. Show the location of each thermostat on the floor plan.
   6. Provide separate graphics showing the chilled and heating water system flow diagram. Show temperatures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.
   7. Provide a graphic showing the steam system flow diagram. Show pressures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.
E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:
   1. Home page to include a minimum of six critical points: Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, KW, etc.
   2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.
   3. Detailed graphics for each mechanical system including AHUs, ERUs, EFs, chillers, and boilers, as a minimum.
   4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.
F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:
   1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.
   2. TCS Bill of Material for each system, e.g. AHU, RTU, FCU, boiler, etc.
   3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.03 CONDUIT INSTALLATION

A. Conduit Sizing and Installation: Refer to Electrical Section 26 05 33 for execution and installation.
   1. Thermostats/temperature sensors shall be installed in junction boxes, flush with the wall, and shall be coordinated for orientation with Architect/Engineer.

3.04 WIRE AND CABLE INSTALLATION

A. Field Quality Control:
   1. Inspect wire and cable for physical damage and proper connection.
   2. Torque test conductor connections and terminations to manufacturer's recommended values.
   3. Perform continuity test on all conductors.
   4. Protection of cable from foreign materials:
      a. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.
      b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum
      c. cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

B. B. Installation Schedule:
   1. Conduit terminations to all devices installed in applications with rotating equipment, expansion/contraction or vibration shall be made with flexible metallic conduit, unless noted otherwise. Final terminations to exterior devices installed in damp or wet locations shall be made with liquid tight flexible metallic conduit. Terminations in hazardous areas, as defined in the National Electrical Code, shall be connected using flexible conduit rated for the environment.

3.05 FMCS INSTALLATION

A. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for full ampacity of wiring or overcurrent protection of circuit controlled.

B. Naming Conventions: Coordinate all point naming conventions with Owner standards. In the absence of Owner standards, naming conventions shall use equipment designations shown on plans.

3.06 COMMISSIONING

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 ensure 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 FMCS system operation.

C. This Contractor shall prove that the controls network is functioning correctly and within acceptable bandwidth criteria and shall test the system with an approved protocol analysis tool. Provide a log and statistics summary showing that each channel is within acceptable parameters. Each channel shall be shown to have at least 25% spare capacity for future expansion.

D. Upon completion of the performance tests described above, repeat these tests, point by point, as described in the validation log above in the presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.07 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified. Observe that heating cannot begin at TAB reheat terminals until the unit is at the minimum cfm.

E. Verify the operation of all interlock systems.

3.08 TEST AND BALANCE COORDINATION

A. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Contractor shall provide a minimum of four (4) hours training for the Balancing Contractor in the use of these tools.

C. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process until the first 20 terminal units are balanced.

D. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.09 DEMONSTRATION AND ACCEPTANCE

A. A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of

B. all controls and systems. Describe the normal operation of all equipment.

3.10 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 8 hours of training on consecutive days for 4 Owner's representatives. The training course shall enable the Owner's representatives to perform Day-to-Day Operations as defined

herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

B. Day-to-Day Operations - Training Description:
   1. Proficiently operate the system.
   2. Understand control system architecture and configuration.
   3. Understand FMCS systems components.
   4. Understand system operation, including FMCS system control and optimizing routines (algorithms).
   5. Operate the workstation and peripherals.
   6. Log-on and off the system.
   7. Access graphics, point reports, and logs.
   8. Adjust and change system setpoints, time schedules, and holiday schedules.
   9. Recognize malfunctions of the system by observation of the printed copy and graphic visual signals.
   10. Understand system drawings and Operation and Maintenance manual.
   11. Understand the job layout and location of control components.
   12. Access data from FMCS controllers and ASCs.
   13. Operate portable operator's terminals.

C. Advanced Operations - Training Description:
   1. Make and change graphics on the workstation.
   2. Create, delete, and modify alarms, including annunciation and routing of these.
   3. Create, delete and modify point trend logs and graph or print these both on and ad-hoc basis and at user-definable time intervals.
   4. Create, delete, and modify reports.
   5. Add, remove, and modify system's physical points.
   6. Create, modify and delete programming.
   7. Add panels when required.
   8. Add operator interface stations.
   9. Create, delete, and modify system displays, both graphic and others.
   10. Perform FMCS system field checkout procedures.
   11. Perform FMCS controller unit operation and maintenance procedures.
   12. Perform workstation and peripheral operation and maintenance procedures.
   13. Perform FMCS system diagnostic procedures.
   14. Configure hardware including PC boards, switches, communication, and I/O points.
   15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
   16. Adjust, calibrate, and replace system components.

D. System Management - Training Description:
   1. Maintain software and prepare backups.
   2. Interface with job-specific, third-party operator software.
   3. Add new users and understand password security procedures.

E. Provide course outline and materials in accordance with the "SUBMITTALS" article in Part 1 of this section.

F. The instructor(s) shall provide one copy of training material per student.

END OF SECTION 23 09 23

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SECTION 23 11 23

FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Joining materials.
4. Manual gas shutoff valves.
5. Pressure regulators.
6. Unions and Flanges

1.02 DEFINITIONS

A. CWP: Cold working pressure.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.

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

D. 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.

1.03 SUBMITTALS

A. Product Data:

1. Piping specialties.
2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Pressure regulators. Indicate pressure ratings and capacities.
4. Dielectric fittings.

B. Certificates:

1. Welding certificates.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section IX of the ASME Boiler and Pressure Vessel Code and/or the National Certified Pipe Welding Bureau.
2. Welding procedures, welders, and welding operators for natural gas piping to be in accordance with certified welding procedures of the National Certified Pipe Welding Bureau.
3. Architect or Engineer reserves the right to test and inspect work of any welder employed on Project, at Contractor's expense. If work of welder is unsatisfactory, welder shall be prevented from doing further welding on Project.

1.06 DELIVERY, STORAGE, AND HANDLING

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

B. Promptly inspect shipments to ensure material is undamaged and complies with Specifications.

C. 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.

D. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight. Cover pipe to eliminate rust and corrosion while allowing ventilation to avoid condensation.

E. Do not store materials directly on grade. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

1.07 DESIGN CRITERIA

A. Use only new material, free of defects, rust and scale, and meeting latest revision of ASTM specifications as listed in this Specification.

B. Construct all piping for the highest pressures and temperatures in the respective system in accordance with ANSI B31, but not less than 125 psig unless specifically indicated otherwise.

C. Non-metallic piping will be acceptable only for the services indicated. It will not be acceptable in occupied spaces and ventilation plenum spaces, including plenum ceilings.

D. Where weld fittings are used, use only long radius elbows having centerline radius of 1.5 pipe diameters.

E. Steel piping and fittings shall be manufactured in the United States.

F. Facility natural gas piping systems shall be installed and tested in accordance with all State and applicable codes.

1.08 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. New Natural-Gas Service: Connection from main in street or other location to gas meter and gas meter will be provided by local gas utility. Coordinate with the local gas utility.

1.09 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed and concealed behind finished surfaces.

C. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 22 05 53 "Identification of Plumbing Piping and Equipment."

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Obtain each product type from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 54 and the International Fuel Gas Code.

B. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 125 psig minimum unless otherwise indicated.
2. Minimum Operating Pressure of Service Meter: 20 psig.

C. Natural-Gas System Pressure within Buildings:

1. Single Pressure: 2 psig.

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.

2.03 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

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

2.04 PIPING SPECIALTIES

A. Weatherproof Vent Cap:

1. 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.

2.05 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.

2.06 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: 150 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. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves NPS 1-1/4 to NPS 2 having 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: 175 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" permanently marked on valve body.

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

1. Manufacturers: Crane, Walworth, Jenkins, Nibco, Apollo, Milwaukee or Southern Manufacturing Company.
2. Body: Bronze, complying with ASTM B584.
3. Ball: Chrome-plated bronze or stainless steel.

4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
8. CWP Rating: 175 psig.

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

1. Manufacturers: Crane, Walworth, Jenkins, Nibco, Apollo, Milwaukee or Southern Manufacturing Company.
2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 175 psig.

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

1. Manufacturers: Crane, Walworth, Jenkins, Nibco, Apollo, Milwaukee or Southern Manufacturing Company.
2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 175 psig.

2.07 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 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80A.

1. Manufacturers: Fisher, Kunkle, Maxitrol, or Dormont.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: UV-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to regulator.

9. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig.

2.08 UNIONS AND FLANGES

A. 2 Inches and Smaller

1. Description:
   a. Standard: ASTM A197/ANSI B16.3 malleable iron unions with brass seats.
      1) Use black malleable iron on black steel piping and galvanized malleable iron on galvanized steel piping.
   b. Pressure Rating: Use unions of pressure class equal to or higher than that specified for fitting of respective piping service but not less than 250 psig.
   c. End Connections: Threaded.

B. 2-1/2” and Greater

1. Description:
   a. Standard: ASTM A181 or A105, grade 1 hot forged steel flanges.
   b. Pressure Rating: Use unions of pressure class equal to or higher than that specified for fitting of respective piping service End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
   c. End Connections: threaded, welding neck, or slip-on pattern.
      1) Use raised face flanges ANSIB16.5 for mating with other raised face flanges on equipment with flat ring or full face gaskets.
      2) Use ANSI B16.1 flat face flanges with full face gaskets for mating with other flat face flanges on equipment.
      3) Gasket material to be non-asbestos and rated for pressures and temperatures of piping system.

PART 3 - EXECUTION

3.01 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.

3.02 PREPARATION

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

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

C. Comply with applicable code requirements for preventing accidental ignition.

3.03 INSTALLATION OF OUTDOOR PIPING

A. Comply with NFPA 54 and 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. 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.

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

E. Install pressure gauge upstream and downstream from each service regulator. Pressure gauges are specified in Section 23 05 19 "Meters and Gauges for HVAC Piping."

3.04 INSTALLATION OF INDOOR PIPING

A. Comply with NFPA 54 and 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. Do not install piping in concealed locations unless sleeved with the sleeve open at both ends.

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. Remove foreign material from interior and exterior of pipe and fittings.

G. Install piping parallel to building walls and ceilings and at heights to not obstruct any portion of window, doorway, stairway, or passageway. Where interferences develop in field, offset or reroute piping to clear interferences. In all cases, consult Drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

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

I. "Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (½) the diameter of the main.

J. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including required service space for this equipment, unless the piping is serving this equipment.

K. Install valves and piping specialties, including items furnished by other sections of work, as specified and detailed. Make connections to equipment installed by other sections of work where equipment requires the piping services indicated in this Section.

L. Where installing piping above accessible ceilings, allow sufficient space for ceiling panel removal.

M. Locate valves for easy access. Do not locate valves within return air plenums.

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

O. Install piping free of sags and bends.

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

Q. Verify final equipment locations for roughing-in.

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

S. 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.
2. Install sediment trap on both sides of regulators for gas reduction to 2 psig with valve and capped.

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

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

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

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping and containment conduit in cast-in-place concrete floors. Containment conduit to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Containment conduit may not be in physical contact with other metallic structures

such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

a. Containment conduit to be vented.

3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

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

5. Prohibited Locations:

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

b. Do not install natural-gas piping in solid walls or partitions.

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

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

Y. 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.

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

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

BB. Install pressure gauge upstream and downstream from each line regulator.

CC. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

DD. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

EE. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.05 INSTALLATION OF VALVES

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install main shutoff valve upstream of the first branch line. The main shutoff valve shall be installed in the first available location inside the building that provides ready access.

E. Install anode for metallic valves in underground PE piping.

F. Do not install valves in return-air plenums.

3.06 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 in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

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

3.07 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

B. Install hangers for steel piping with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support vertical runs of corrugated stainless steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.08 PIPING CONNECTIONS

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

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

C. Where installing piping adjacent to appliances, allow space for 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.

3.09 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.10 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test, inspect, and purge natural gas in accordance with the International Fuel Gas Code and authorities having jurisdiction.
2. Verify that the piping system being tested is fully connected to all components and that all equipment is properly installed, wired, and ready for operation. If required for the additional pressure load under test, provide temporary restraints at expansion joints or isolate them during the test. Verify that hangers can withstand any additional weight load that may be imposed by the test.
3. Provide all piping, fittings, blind flanges, and equipment to perform the testing.
4. Conduct pressure test with test medium of air unless specifically indicated. Minimum test time 24 hours at 100 psig; additional time may be necessary to conduct an examination for leakage. If leaks are found, repair the area with new materials and repeat the test; caulking will not be acceptable.
5. For air tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. The piping system exclusive of possible localized instances at pump or valve packing shall show no evidence of leaking. After testing is complete, slowly release the pressure in a safe manner.
6. Measure natural gas system test pressure with a water manometer or an equivalent device calibrated in increments not greater than 0.1 inch water column. System will not be approved until it can be demonstrated that there is no measurable loss of test pressure during the test period.
7. All pressure tests are to be documented on a form included in this specification.
8. On piping that cannot be tested because of connection to an active line, provide temporary blind flanges and hydrostatically test new section of piping. After completion of test, remove temporary flanges and make final connections to piping. Die penetrate test pass weld or x-ray the piping that was not hydrostatically tested up to the active system.
9. Natural-gas piping will be considered defective if it does not pass tests and inspections.

B. Prepare test and inspection reports.

3.11 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping is to be one of the following:

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

3.12 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5 PSIG

A. Aboveground, distribution piping 2” and smaller is to be the following:

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

B. Aboveground, distribution piping 2-1/2” and greater to be the following:

1. Steel pipe with steel welding fittings and welded joints.

3.13 ABOVEGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Distribution piping valves for pipe sizes NPS 2 and smaller are to be the following:

1. Two-piece, full regular-port, bronze ball valves with bronze trim.
2. Two-piece, full -port, bronze ball valves with bronze trim.

B. Distribution piping valves for pipe sizes NPS 2-1/2 and larger are to be one the following:

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

C. Valves in branch piping for single appliance are to be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION 23 11 23

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Valves and specialties.
3. Refrigerants.

1.02 SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and refrigerant piping specialty.

B. Shop Drawings:

1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
2. Show interface and spatial relationships between piping and equipment.

C. Field quality-control reports.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.04 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

C. Order all copper refrigeration tube with each shipping unit marked with the purchase order number, metal or alloy designation, temper, size, and name of supplier; with soft straight lengths or coils identified with a tag indicating that the product was manufactured in accordance with ASTM B280; and with each hard temper straight length identified throughout its length by a blue colored marking not less than 3/16 inch in height and a legend at intervals of not greater than three feet that includes the designation "ACR" and pipe outside diameter.

D. Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the Owner.

1.05 DESIGN CRITERIA

A. Use only new material, free of defects and scale, and meeting the latest revision of ASTM specifications as listed in this specification.

B. Where ASTM B88, type L hard temper copper tubing is specified, ASTM B88, type K hard temper copper tubing may be substituted at Contractor's option.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

B. Prepare valves and specialties for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads and other end connections.

C. Use the following precautions during storage:

1. Maintain valve and specialty end protection.
2. Store valves and specialties 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

2.01 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

B. All refrigerant piping specialties shall have a maximum working pressure of full vacuum to 500 psig and a maximum working temperature of 225 deg F.

C. For systems utilizing R-410A, provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 850 psig and a maximum working temperature of 225 deg F.

2.02 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B88 type L cleaned and capped in accordance with ASTM B 280, Type ACR.

B. Wrought-Copper Fittings, Solder-Joint: ASME B16.22.

C. Wrought-Copper Fittings, Brazed-Joint: ASME B16.50.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

F. Brazing Filler Metals: AWS A5.8/A5.8M.

G. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.03 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping:

1. Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.02 INSTALLATION OF PIPING, GENERAL

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

B. Install refrigerant piping according to ASHRAE 15.

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

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

E. Do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

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

G. Install piping adjacent to machines to allow service and maintenance.

H. Install piping free of sags and bends.

I. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

J. Do not install piping running through any elevator shaft, public stairway, stair landing, or means of egress.

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

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

M. Refer to Section 23 09 23 "Direct Digital Control (DDC) System for HVAC" control wiring and sequence of operation.

N. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

O. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

P. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

Q. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

R. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

T. Identify refrigerant piping and valves according to Section 23 05 53 "Identification for HVAC Piping and Equipment."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.03 PIPE JOINT CONSTRUCTION

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

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

C. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

3.04 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints in Section 23 05 48 "Vibration Controls for HVAC."

B. Comply with Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

C. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.06 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers, not exceeding 1500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.07 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round and ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Requirements:

1. Section 23 05 48.13 "Vibration Controls for HVAC" for seismic restraint devices and installation.
2. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
3. Section 23 31 16 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
4. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.02 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of all duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated Design Submittals:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

D. Field quality-control reports.

1.03 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports are to withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

C. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.02 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.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to washdown (Parking Levels P2-P6, 1st Level Parking Entry, Bus Waiting (Interior)), construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with 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."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with 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." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 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."

2.03 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to washdown (Parking Levels P2-P6, 1st Level Parking Entry, Bus Waiting (Interior)), construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
3. 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. Elgen Manufacturing.
    b. GSI; a DMI Company.
    c. Linx Industries; a DMI company (formerly Lindab).
    d. McGill AirFlow LLC.
    e. MKT Metal Manufacturing.
    f. Nordfab Ducting.
    g. SEMCO, LLC; part of FlaktGroup.
    h. Set Duct Manufacturing.
    i. Sheet Metal Connectors, Inc.
    j. Spiral Manufacturing Co., Inc.
    k. Stamped Fittings Inc.

B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.04 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Reinforcement Shapes and Plates: ASTM A36/A36M, 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.

E. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.05 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with 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. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.07 SEALING AND FIRESTOPPING

A. Non-Rated Partitions

1. Annular space between duct (with or without insulation) and the non-rated walls or floor opening shall not be larger than 2".
2. Where existing openings have an annular space larger than 2", the space shall be patched to match existing construction to within 2" around the duct.
3. Where shown or specified, pack annular space with fiberglass batt insulation or mineral wool insulation. Provide 4" sheet metal escutcheon around duct on both sides of partition or floor to cover annular space.

B. Fire, Smoke, and Fire/Smoke Rated Surfaces

1. Firestop systems shall be UL listed or tested by independent testing laboratory, approved by State and Local Code jurisdictions. Use a product that has a rating not less than rating of wall or floor being penetrated. Sleeves in concrete to be minimum 16 gauge galvanized steel sleeves.

PART 3 - EXECUTION

3.01 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 in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.02 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 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.

3.03 DUCTWORK EXPOSED TO WASHDOWN

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork is to be Type 304 stainless steel.
2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 23 07 13 "Duct Insulation." If closed cell elastomeric insulation, jacketing is not required.

3.04 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.05 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.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.06 DUCTWORK 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.

3.07 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.

3.08 SEALING AND FIRESTOPPING

A. Coordinate location of building surface penetrations with appropriate contractors. Furnish sleeves, inserts, and other devices to be built into structure to contractor performing Work. Prepare Shop Drawings for approval for penetrations of structural elements, including floor slabs,

shear walls, and bearing walls. Do not allow penetrations to be made until Shop Drawings are approved.

B. Non-Rated Partitions:

1. Completely seal (or caulk) around duct penetrations through non-rated, smoke tight corridor walls in healthcare facilities. Refer to architectural drawings for additional information.
2. Completely seal duct penetrations, as specified below, for walls of the following rooms below:
   a. Non-fire rated mechanical rooms
   b. Computer rooms
   c. Conference rooms
   d. Private offices

3. Install sheet metal blank-off plates and caulk where ducts penetrate non-fire rated surfaces. Size units to accommodate insulation, where applicable.
4. Install galvanized sheet metal sleeves in hospital corridor wall penetrations to provide backing for sealant. Apply sealant to both sides of penetration in manner that annular space between duct sleeve and duct or insulation is completely blocked.

C. For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:

1. Duct penetrations. Provide 2”x 2” x 1/8” galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8”on center. Seal corners water tight with urethane caulk.
2. Floors subject to water intrusion or rooms housing electrical equipment include the following locations:
   a. Restrooms
   b. Janitor Rooms w/ Sinks
   c. Mechanical/Plumbing Equipment Rooms
   d. Chemical/Hazardous Waste Storage
   e. Vehicle Storage and Parking Ramps
   f. Data/Telecommunications Rooms
   g. Electrical Equipment Rooms

D. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations:

1. Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 84 13 "Penetration Firestopping."
   a. UL listed or tested by independent testing laboratory, approved by State and Local Code jurisdictions. Use a product that has a rating not less than rating of wall or floor being penetrated. Sleeves in concrete to be minimum 16 gauge galvanized steel sleeves.
   b. Install products in accordance with the manufacturer's instructions where pipe penetrates a fire rated surface.
   c. When duct is insulated, use product that maintains integrity of insulation and vapor barrier.

d. Where sleeve must be installed in existing floor, grout area around sleeve to restore floor integrity.
e. In wet area floor penetration, top surface of penetration to be 2 inches above adjacent floor with additional height obtained by means of concrete pad poured integral with floor. Wet areas for this Paragraph are rooms or spaces containing air handling unit coils, convertors, pumps, chillers, boilers, and similar equipment.

3.09 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. Supply Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
   b. Exhaust Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
   c. Outdoor-Air Ducts with a Pressure Class of 2 Inch wg or Higher: Test representative duct sections totaling no less than 50 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. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. 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.
7. Leakage rate shall not exceed more than 5% of the system air quantity for 2” of lower pressure class ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
8. Leakage rate shall not exceed more that 1% of the system air quantity for 3” or higher pressure class ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
9. Give seven days' advance notice for testing.

C. Structural Tests:

1. Random test all ductwork per A/E direction. Do not insulate ductwork until it has been successfully tested.
2. Test pressure shall be equal to the duct pressure class.
3. Deflection limits shall not exceed those listed in accordance with Chapter 11 of SMACNA HVAC Duct Construction Standards, 3.0 Performance Requirements.
4. Submit a signed report to the A/E Representative, indicating test apparatus used, results of the structural test, and any remedial work required

D. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

E. Duct system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.10 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and 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.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. 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 in accordance with NADCA ACR. 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 in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.11 STARTUP

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive 2 inch wg.
2. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   a. Pressure Class: Positive 3 inch wg.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative 2 inch wg.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 2 inch wg.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
   a. Pressure Class: Positive or negative 2 inch wg.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2 inch wg.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel
2. Stainless Steel Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

G. Elbow Configuration:

1. Rectangular Duct - Requirements for All Velocities: 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."
2. 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) 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: Standing seam.

DUCT LEAKAGE TEST REPORT

Project	**Name:**_____	
	Location:_____	
	Contractor:_____	
	Date:_____	
System Data	**Fan No:**_____	**Leakage Class (C_L):**_____
	Fan Design CFM:_____	**Duct Pressure Class (P_C):**_____
		Test Pressure (P_T):_____
Test Equipment	**Manufacturer:**_____	**Model No:**_____ **Serial No:**_____

For large systems, use the reverse side for a simple sketch of the entire duct system. Then use letter designations to indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Note that due to normal construction sequencing it is usually necessary to test risers separately prior to enclosing chases.

Design Data					Field Test Data							
			Allowable Leakage		Diameter		Pressure (in. wc.)					
Duct Section	Duct Shape	Duct Surface (Ft^2)	Leakage Factor ($P^{.65}C_L$)	CFM for Section	Tube (D_1)	Orifice (D_2)	In Duct (P)	Across Orifice (P_{drop})	Date	Performed By	Observed By	Actual CFM
TOTAL												

DUCT STRUCTURAL TEST REPORT _____

Project **Name:**_____

Location:_____

Contractor:_____

System Data **Fan No:**_____

Describtion of Test Method:

_____

_____

_____

Test Equipment **Manufacturer:**_____ **Model No:**_____ **Serial No:**_____

For large systems, use the reverse side for a simple sketch of the entire duct system. Then use letter designations to indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Note that due to normal construction sequencing it is usually necessary to test risers separately prior to enclosing chases.

Design Data								Field Test Data						
Duct Test Location	Ductwork Shape		Duct Pressure Class	Allowable Ductwork Wall Deflection		Allowable Joint/ Reinforcement Deflection		Pressure (in. wc.) In Duct	Measured Ductwork Wall Deflection		Measured Joint/ Reinforcement Deflection		Per-formed By/ Date	Wit-nessed By/ Date
	H	W		H	W	H	W		H	W	H	W		

END OF SECTION 23 31 13

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Control dampers.
3. Fire dampers.
4. Flange connectors.
5. Duct silencers.
6. Turning vanes.
7. Duct-mounted access doors.
8. Duct access panel assemblies.
9. Flexible connectors.
10. Duct accessory hardware.

B. Related Requirements:

1. Section 23 33 46 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 23 37 23 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
3. Section 28 46 21.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
4. Section 28 46 21.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.03 SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
   e. Include diagrams for power, signal, and control wiring.

C. Source quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.05 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

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.

2.02 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Balance
   b. Kees
   c. Nailor Industries
   d. Ruskin
   e. Vent Products Company Inc.,
   f. Or approved equal.
2. Performance:
   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
3. Construction:
   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
   c. Construct dampers in multiple sections with mullions where width is over 48 inches.
   d. Provide operators with locking devices and damper position indicators for each damper.
   e. Use elevated platform on insulated ducts.
   f. Provide end bearings or bushings for volume damper rods penetrating ductwork constructed to 3 inch W.C. pressure class or above.
4. Frames:
   a. Hat-shaped, 16-gauge- thick, galvanized sheet 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. Reinforce blades to prevent vibration, flutter, or other noise.
d. Galvanized steel; 16 gauge thick.

6. Blade Axles: Galvanized steel.
7. Bearings:
   a. Oil-impregnated stainless steel sleeve.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

2.03 FIRE DAMPERS

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

1. Air Balance,
2. Advanced Air,
3. American Warming and Ventilating,
4. Cesco,
5. Greenheck,
6. Nailor,
7. National Control Air,
8. Safe-Air,
9. Phillips-Aire,
10. Prefco,
11. Ruskin.
12. Or approved equal.

B. Type:

1. Static [**and**] dynamic; rated and labeled in accordance with UL 555 by an NRTL.
2. Dampers shall meet requirements of NFPA 90A.
3. Dampers shall be Type B.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed galvanized sheet steel. Material gauge is to be in accordance with UL listing.

I. Horizontal Dampers: Include blade lock and stainless steel closure spring.

J. Heat-Responsive Device:

1. Replaceable, 165 deg F rated, fusible links.

2.04 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.05 DUCT SILENCERS

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

1. Vibro Acoustics
2. Or approved equal.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Rectangular elbow with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A653/A653M, G90**,** galvanized sheet steel, 18 gauage thick.

E. Inner Casing and Baffles: ASTM A653/A653M, G90 galvanized sheet metal, 22 gauge thick, and with perforations.

F. Special Construction:

1. Suitable for outdoor use.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.
   a. Fill Material: Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data.

Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be resilient such that it will not crumble or break, and conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.

b. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

3. Joints: Lock formed and sealed or stick welded and sealed.
4. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
5. Reinforcement: Cross or trapeze angles for rigid suspension.

I. Source Quality Control:

1. Test in accordance with ASTM E477.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000 fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.06 TURNING VANES

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

1. Aero Dyne
2. Anemostat
3. Barber-Colman
4. Hart & Cooley
5. Or approved equal.

B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply 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."

D. Vane Construction:

1. Double wall.
2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.07 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. 24-gauge- thick galvanized steel door 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: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   a. 24-gauge- thick galvanized steel.
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 and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.08 FLEXIBLE CONNECTORS

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

1. Anco Products
2. Clevaflex
3. Thermaflex
4. Flexmaster
5. Or approved equal.

B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Materials: Flame-retardant or noncombustible fabrics.

E. Coatings and Adhesives: Comply with UL 181, Class 1.

F. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4 inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

G. 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.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.09 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.

2.10 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No. 2 finish for exposed ducts.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

D. Tie Rods: Galvanized steel, **1/4-inch** minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, 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 steel volume dampers in 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 and as needed for testing and balancing.

H. Install fire dampers in accordance with UL listing.

I. Connect ducts to duct silencers rigidly.

J. 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. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-ft. spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 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.

M. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.02 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 size and location of access doors are adequate to perform required operation.
3. Operate fire dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. 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 33 19

FIXED LOUVERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Fixed extruded-aluminum louvers.
2. Blank-off panels for louvers

1.02 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).

C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

D. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing in accordance with AMCA 500-L.

E. Windborne-Debris-Impact-Resistant Louver: Louver that provides specified windborne-debris-impact resistance, as determined by testing in accordance with AMCA 540.

1.03 SUBMITTALS

A. Product Data: For each type of product.

1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
2. Show mullion profiles and locations.

C. Samples: For each type of metal finish required.

D. Windborne-debris-impact-resistance test reports.

1.04 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.05 WARRANTY

A. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of baked enamel, powder coat, or organic finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
   b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Warranty Period: 10 years from date of Substantial Completion.

B. Special Finish Warranty, Anodized Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of anodized finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
   b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
   c. Cracking, peeling, or chipping.
2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Louvers withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures are considered to act normal to the face of the building.

1. Wind Loads:
   a. Determine loads based on a uniform pressure of 20 lbf/sq. ft. acting inward or outward.

B. Windborne-Debris-Impact Resistance: Louvers located within 30 feet of grade pass basic protection, when tested in accordance with AMCA 540.

C. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 500-L.

D. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.02 FIXED EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Drainable-Blade, Windborne-Debris-Impact-Resistant Louver, Extruded Aluminum:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Airolite Company, LLC (The).

b. Greenheck Fan Corporation.

2. Louver Depth: 6 inches (unless scheduled differently).
3. Frame and Blade Nominal Thickness: Not less than 0.081 inch.
4. Mullion Type: Exposed.
5. Louver Performance Ratings:
   a. Free Area: Not less than 56% for 48-inch- wide by 48-inch- high louver.
   b. Point of Beginning Water Penetration: Not less than 989 fpm.
   c. Air Performance:
      1) As Scheduled.
6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
7. AMCA Rating: AMCA 540.

2.03 LOUVER SCREENS

A. General: Provide screen at each exterior louver.

1. Screen Location for Fixed Louvers: Interior face.
2. Screening Type: Bird screening.

B. Secure screen frames to louver frames with machine screws with heads finished to match louver, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.

1. Metal: Same type and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
2. Finish: Same finish as louver frames to which louver screens are attached.
3. Type: Rewirable frames with a driven spline or insert

D. Louver Screening for Aluminum Louvers:

1. Bird Screening, Aluminum: 1/2-inch- square mesh, 0.063-inch wire.

2.04 MATERIALS

A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B209, Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.

1. For fastening aluminum, use aluminum or 300 series stainless steel fasteners.
2. For fastening stainless steel, use 300 series stainless steel fasteners.
3. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless steel components, with allowable load or strength design capacities calculated in accordance with ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing in accordance with ASTM E488/E488M conducted by a qualified testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.05 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.

C. Maintain equal louver blade spacing**,** including separation between blades and frames at head and sill, to produce uniform appearance.

D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

1. Frame Type: Channel unless otherwise indicated.

E. Include supports, anchorages, and accessories required for complete assembly.

F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches o.c., whichever is less.

1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades, so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.
3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.

G. Provide subsills made of same material as louvers or extended sills for recessed louvers.

H. Join frame members to each other and to fixed louver blades with fillet welds concealed from view, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.06 ALUMINUM FINISHES

A. Finish louvers after assembly.

B. Baked-Enamel or Powder-Coat Finish: AAMA 2603. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.02 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.03 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 07 92 00 "Joint Sealants" for sealants applied during louver installation.

3.04 ADJUSTING AND CLEANING

A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 23 33 19

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SECTION 23 33 46

FLEXIBLE DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Insulated flexible ducts.

1.03 SUBMITTALS

A. Shop drawings and product data shall be specifically prepared for this project. Incomplete or generic shop drawings will not be acceptable.

B. Product Data: For each type of product.

C. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

PART 2 - PRODUCTS

2.01 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.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

2.02 INSULATED FLEXIBLE DUCTS

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

1. Anco Products,
2. Clevaflex,
3. Thermaflex,
4. Flexmaster
5. Wiremold,

6. Or approved equal.

B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene aluminized vapor-barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 deg F.
4. Insulation R-Value: R6.

2.03 FLEXIBLE DUCT CONNECTORS

A. Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action.

B. Nylon strap to suit duct size.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect diffusers to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

D. Flexible Duct Connections (Insulated Flexible Duct)

1. Secure inner liner of flexible duct to metal duct with stainless steel metal band clamp.
2. Secure outer vapor barrier of flexible duct to metal duct with nylon draw band.

E. Flexible Duct Connections (Non-Insulated Duct)

1. Secure flexible duct to metal duct with stainless steel metal band clamp.

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

H. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.

3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 23 33 46

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SECTION 23 34 16

CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Square in-line centrifugal fans.
2. Tubular in-line centrifugal fans.

1.02 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
5. 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. Field quality-control reports.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 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.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.02 SQUARE IN-LINE CENTRIFUGAL FANS

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Carnes Company
4. Or approved equal.

B. Description: Square in-line centrifugal fans.

C. Housing:

1. Housing Material: Galvanized steel.
2. Housing Coating: None.
3. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Drive Units: Motor mounted in airstream, factory wired to NEMA 4X disconnect switch located on outside of fan housing.

E. Bearings:

1. Heavy duty ball bearing type to match with the fan load.

F. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

G. Motor Enclosure: Totally enclosed, fan cooled.

H. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Companion Flanges: For inlet and outlet duct connections.

2.03 TUBULAR IN-LINE CENTRIFUGAL FANS

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

1. Loren Cook Company.
2. Or approved equal.

B. Description: Tubular in-line centrifugal fans.

C. Housing:

1. Housing Material: Welded and bolted construction utilizing corrosion resistant fasteners. Minimum 14 gauge steel with inte

2. Housing Coating: Electrostatically applied, baked polyester powder coating on all steel fan components. Minimum 2mil thick baked powder finish which must exceed 1,000 hour salt spray under ASTM B117 test method.
3. Housing Construction: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Fan Wheels: Steel, non-overloading, high efficiency mixed-flow type. Contoured single thickness blades shall incorporate 3-D curvature for maximum efficiency across the entire surface of the blade. Blades shall be continuously welded to the backplate and inlet shroud. Hubs shall be keyed and securely attached to the motor shaft. Wheel shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

E. Motor Enclosure: Totally enclosed, fan cooled.

F. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Companion Flanges: For inlet and outlet duct connections.

2.04 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. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.05 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.

D. Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK AND PIPING CONNECTIONS

A. 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. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

D. Install heat tracing on all drain piping subject to freezing temperature and as indicated on Drawings.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.05 STARTUP SERVICE:

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.

3. 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.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
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 confirm proper motor rotation and unit operation, 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.

3.06 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Lubricate bearings.

C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.07 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Fans and components will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 23 34 16

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SECTION 23 34 23

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Centrifugal ventilators - roof downblast.

1.03 SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Prefabricated roof curbs.
9. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

1.05 MAINTENANCE MATERIALS

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

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.02 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

A. MANUFACTURERS

1. Subject to compliance with requirements, provide products by one of the following:
   a. Greenheck
   b. Cook
   c. Carnes
   d. Twin City
   e. Or approved equal.

B. Housing: Downblast; removable spun-aluminum dome top and outlet baffle spun aluminum; square, one-piece aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted on fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Spark-resistant, all-aluminum wheel construction.
5. Mounting Pedestal: Galvanized steel with removable access panel.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Overall Height: 24 inches.
2. Sound Curb: Curb with sound-absorbing insulation.
3. Hinged sub-base to provide access to damper or as cleanout for grease applications.
4. Pitch Mounting: Manufacture curb for roof slope.

5. Metal Liner: Galvanized steel.
6. Mounting Pedestal: Galvanized steel with removable access panel.

2.03 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."

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.

2.04 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.

D. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install power ventilators level and plumb.

B. Install all manufacturer furnished accessories as specified herein.

C. Equipment Mounting:

1. Secure roof-mounted fans to roof curbs with zinc-plated hardware.
2. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
3. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

D. Install units with clearances for service and maintenance.

E. Furnish wall and roof opening locations and dimensions to other sections of work requiring opening information.

F. Label units according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK CONNECTIONS

A. 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. Horizontal duct under the bottom of roof exhaust fans shall have a 2” deep drip pan centered under roof opening below the roof exhaust fan throat. Seams in bottom pan shall be soldered or caulked watertight.

3.03 ELECTRICAL CONNECTIONS

A. The Division 26 Contractor shall perform the work under this section.

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 05 53 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.05 STARTUP SERVICE:

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. 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.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
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 confirm proper motor rotation and unit operation, 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.

3.06 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Lubricate bearings.

C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.07 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.
3. Fans and components will be considered defective if they do not pass tests and inspections.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 23 34 23

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SECTION 23 37 13

GRILLES, REGISTERS, AND DIFFUSERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Louver face diffusers.
3. Registers and Grilles (Fixed or Adjustable Blade)
4. Spiral duct mounted grilles.
5. Egg Crate Grilles

B. Related Requirements:

1. Section 23 33 00 "Air Duct Accessories" for fire dampers and volume-control dampers not integral to diffusers.

1.03 SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.01 GENERAL

A. Grilles, registers, and diffusers shall be provided with appropriate frames compatible with ceiling types. Coordinate ceiling types with other trades.

B. Finishes are specified herein. Verify finishes with Architect prior to ordering grilles. Submit color charts for custom finishes were applicable.

C. Registers shall be provided with opposed blade dampers.

2.02 MANUFACTURERS

A. Carnes, Krueger, Metalaire, Titus, Price, Nailor, Greenheck, or Tuttle & Bailey.

1. Acceptable manufacturers for specific products are listed under each item.

2.03 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Three Cone:

1. Carnes S Series, Krueger 1400 series, Metalaire 5700/5800 series, Titus TMS, or Price SCD

B. Plaque

1. Carnes S Series, Krueger PLQ, Metalaire 5750/5850 series, Titus OMNI, or Price SPD.

C. Devices shall be specifically designed for variable-air-volume flows.

D. Material: Steel unless otherwise indicated on Drawings.

E. Finish: Baked enamel, white unless otherwise indicated on Drawings.

F. Face Style: Three cone or plaque as indicated on Drawings.

G. Mounting, pattern, and damper requirements shall be indicated on Drawings.

2.04 LOUVER FACE DIFFUSERS

A. Carnes S series, Kruger SH series, Metalaire 5000/5500 series, Titus TDC, or Price SMD/AMD.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: Steel unless otherwise indicated on Drawings.

D. Finish: Baked enamel, white unless otherwise indicated on Drawings.

E. Mounting, pattern, and damper requirements shall be indicated on Drawings.

2.05 GRILLES AND REGISTERS (FIXED OR ADJUSTABLE BLADE)

A. Titus series 300 (supply) and series 350 (return/exhaust); Carnes model R series; EH Price model NM22S/T or C22S/3; Metal Aire series V4000 or H4000; Krueger series 880.

B. Material: Steel, unless noted otherwise on Drawings.

1. Provide aluminum grilles and registers for areas serving high humidity rooms including shower and tub rooms.

C. Finish: Baked enamel, white unless otherwise indicated on Drawings.

D. Face Blade Arrangement:

1. Single or double deflection for supply grilles and supply registers as indicated on Drawings.
2. Single deflection with 0 or 45 degree fixed blade core on return and exhaust registers and grilles.

E. Mounting Frame: Frame type to be appropriate for installation. Screw holes on surface counter sunk to accept recessed type screws.

F. Damper: Indicated on drawings.

2.06 SPIRAL DUCT MOUNTED GRILLES

A. Titus S300; Carnes RDDM series; EH Price SDGE series; Metal Aire 4000PCF; Krueger 5DMGDR

B. Material: Aluminum

C. Finish: Baked anodic finish.

D. Face Blade Arrangement:

1. Aluminum blades, ¾" spacing.
2. Single or double deflection for supply grilles and supply registers as indicated on Drawings.
3. Single deflection with 0 or 45 degree fixed blade core on return and exhaust registers and grilles.

E. Frame: Radius end caps with foam gaskets with 1-3/8" border.

F. Damper: Indicated on drawings.

2.07 EGGCRATE GRILLE

A. Titus model 50; Carnes model RAE or RAT; EH Price model C80; Metal Aire model CC; Krueger model EGC.

B. Material: Aluminum

C. Finish: Baked enamel, white unless otherwise indicated on Drawings.

D. Face: 1/2"x1/2" or 1"x1" grid pattern, 1" deep with a minimum of 85% free area.

E. Mounting Frame: Frame type to be appropriate for installation. Screw holes on surface counter sunk to accept recessed type screws.

F. Damper requirements shall be indicated on Drawings.

2.08 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.02 INSTALLATION

A. Install grilles, registers, and diffusers level and plumb and to provide sight proof view.

B. Grilles and registers shall be securely and neatly attached to building construction or sheet metal duct flanges.

C. Diffusers shall be securely mounted to sheet metal duct construction.

D. Where grilles, registers, or diffusers are permitted to be connected to duct system by flexible duct; inner non metallic metal duct shall be connected using a stainless steel drawband and outer insulation/vapor barrier shall be attached using a plastic or stainless steel drawband. If plastic drawband is used it must be plenum rated. Use of duct tape or insulating tape as means of attachment is not acceptable.

E. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

F. Drop ducts from bottom of supply duct to diffusers shall be same size as diffuser neck duct collar.

G. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

H. Paint ductwork visible behind air outlet and inlets flat black with flat black enamel spray paint.

3.03 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

SECTION 23 41 00

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Flat panel filters.
2. Pleated panel filters.
3. Housings For Panel Filters
4. Housings For Pleated Panel Filters
5. Filter gauges.

B. Related Requirements:

1. Section 23 34 16 "Centrifugal HVAC Fans" for customized fan and filter units.

1.03 SUBMITTALS

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

B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.05 MAINTENANCE 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. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean, dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. 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 52.2 for MERV for methods of testing and rating air-filter units.

B. Comply with NFPA 90A and NFPA 90B.

C. Comply with UL181, UL 586, UL 900.

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.

2.02 MANUFACTURERS

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

1. American Air Filter
2. Air Filters, Inc
3. Barnebey-Cheney
4. Cambridge
5. Continental
6. Flanders
7. Camil-Farr
8. Mine Safety Appliances
9. Research Products, BLC

10. Industries
11. Or approved equal.

2.03 FLAT PANEL FILTERS

A. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Media: Interlaced glass synthetic fibers coated with nonflammable adhesive.

1. Thickness: 1” (or as scheduled)
2. Metal Retainer: Downstream side.
3. Media shall be coated with an antimicrobial agent.

D. Filter-Media Frame: Cardboard with perforated metal retainer sealed or bonded to the media.

E. Nominal Rating: 500 FPM face velocity, 0.15-inch WG initial resistance, 0.50 inches WG recommended final resistance. Average arrestance of filter media shall be 80%.

2.04 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Media: Interlaced glass or Cotton and synthetic fibers coated with nonflammable adhesive. Coat media with an antimicrobial agent.

1. Separators shall be bonded to the media to maintain pleat configuration.
2. Welded-wire grid shall be on downstream side to maintain pleat.
3. Media shall be bonded to frame to prevent air bypass.
4. 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. MERV 13 Rating

F. Nominal Rating: 500 FPM face velocity, 0.20 inch WG initial resistance, 1.0 inches WG recommended final resistance., Average arrestance of filter media shall be 90-92%

2.05 HOUSINGS FOR PANEL FILTERS

A. Description: Manufactured by air handling unit manufacturer, filter media manufacturer, or contractor fabricated. Casing and tracks constructed of galvanized or enameled steel or aluminum. Access to media tracks from outside the casing so media can be readily changed.

B. Source Limitations: Obtain from single source from single manufacturer.

2.06 HOUSINGS FOR PLEATED PANEL FILTERS

A. Description: Housing or holding frame manufactured by filter media manufacturer or the air handling unit manufacturer. Contractor fabricated housings or filter racks will not be accepted. Casing and tracks constructed of galvanized or enameled steel or aluminum. Access to media tracks from outside the casing so media can be readily changed.

B. Source Limitations: Obtain from single source from single manufacturer.

2.07 FILTER GAUGES

A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers:
   a. Dwyer
   b. Or approved equal.

B. Source Limitations: Obtain from single source from single manufacturer.

1. Diameter: 3-1/2 Inches.
2. Scale Range for Panel Filters: 0- to 0.5-inch wg.
3. Scale Range for MERV 7 Filters" 0- to 1.0-inch wg.
4. Scale Range for MERV11, MERV-13, MERV 14: 0- to 2.0-inch wg.

C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION OF FILTERS

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 gauge 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. Coordinate filter installations with duct and air-handling-unit installations.

F. Reinforce filter holding frames per manufacturer's instructions.

G. Maintain necessary clearance for changing filters.

3.03 INSTALLATION OF FILTER GAUGES

A. Install filter gauge for each filter bank.

B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position outside of the unit housing. Adjust and level inclined gauges.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.05 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

3.06 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00

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SECTION 23 51 23

GAS VENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Listed double-wall vents.

1.03 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

B. Shop Drawings: For vents.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

C. Welding certificates.

1.04 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 D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.01 LISTED TYPE B VENTS

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

1. Selkirk-Metalbestos

2. Hart & Cooley
3. General Products Co
4. Metal Fab
5. Or approved equal.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F continuously for Type B; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace for vent sizes up to 6-inches and 1/2-inch for vent sizes greater than 6-inches.

D. Inner Shell: ASTM B209 Aluminum

1. Inner Shell Thickness:
   a. Round up to 6-inches: 0.012”
   b. Round 7-inches to 18”: 0.014”
   c. Round 20” to 24”: 0.018”

E. Outer Jacket: Galvanized steel.

1. Outer Jacket Thickness:
   a. Round up to 6-inches: 28 gauge
   b. Round 7-inches to 18”: 28 gauge
   c. Round 20” to 24”: 24 gauge

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: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: Anti-backdraft.

2.02 VENTS FOR EMERGENCY GENERATORS

A. Construction: ASTM A53, schedule 40, black steel pipe with ASTM A234 150 lb butt welded fittings.

B. Accessories: Provide drain, roof flashing, counter-flashing, and necessary supports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

3.02 GENERAL

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

B. Install vents and accessories in accordance with the manufacturer's recommendations, complying with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading. Minimum support for vertical sections shall be provided at floor penetrations. Support from floor structure, roof structure, or adjacent structural surfaces.

D. Install vents plumb, pitch vents upward from appliance connection to point of termination outside of building.

E. Install vents with a minimum number of joints. Lap joints in direction of flow, align connections accurately, and maintain smooth internal surfaces.

F. Termination of exhaust within 10 feet of operable windows, other building openings, or mechanical air intakes, is not acceptable.

3.03 DOUBLE WALL POSITIVE PRESSURE VENTS

A. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

3.04 VENTS FOR EMERGENCY GENERATOR

A. Install vibration isolation and silencer furnished by the Division 26 Contractor.

B. Install vent with proper pitch for drain.

3.05 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 23 51 23

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SECTION 23 55 33.16

GAS-FIRED UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes gas-fired unit heaters.

1.03 SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For gas-fired unit heaters. Include plans, elevations, sections, and attachment details.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.05 MAINTENANCE 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. Fan Belts: One for each belt-driven fan size.

1.06 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.07 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: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Reznor
2. Sterling
3. Trane
4. Modine
5. Or approved equal

2.02 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.

2.03 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: Powered vented.

D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.

1. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
2. Discharge Louvers: Independently adjustable, horizontal blades.

E. Accessories:

1. Four-point suspension kit.
2. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.

F. Heat Exchanger: Aluminized steel.

G. Burner Material: Aluminized steel with stainless-steel inserts.

H. Propeller Unit Fan:

1. Formed-steel or aluminum propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

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."

2. Enclosure Materials: Rolled steel.
3. Efficiency: Premium efficient.

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. Comply with AGA requirements.
2. Gas Control Valve: Two stage.
3. Ignition: Direct spark ignition.
4. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
5. Vent Flow Verification: Differential pressure switch to verify open vent.
6. Control transformer. Step down, 460V to 115V, 1kVA 1 phase.
7. High Limit: Thermal switch or fuse to stop burner.
8. Thermostat: Devices and wiring are specified in Section 23 09 23.27 "Temperature Instruments."

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54 latest edition, applicable local codes and regulations, and manufacturer's written instructions.

3.02 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.

B. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.

1. Spring hangers are specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
2. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment".

3.03 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 23 "Gas Vents."

E. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.

3.05 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.06 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

END OF SECTION 23 55 33.16

SECTION 23 73 13.16

INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Air filtration.
5. Dampers.

1.03 SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
   a. Include certified fan-performance curves with system operating conditions indicated.
   b. Include certified fan-sound power ratings.
   c. Include fan construction and accessories.
   d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Startup service reports.

B. Field quality-control reports.

C. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.05 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 1 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 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.

B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 4-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch (L/240 ratio) of panel span.

C. Casing Leakage Performance: ASHRAE 111, or better at plus or minus 4 inch wg.

2.02 MANUFACTURERS

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

1. Aaon
2. Daikin Applied.
3. Trane.
4. YORK.
5. Or approved equal.

2.03 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

1. Material: Galvanized steel.
2. Height: 6 inches.

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Double-Wall Construction:

1. Outside Casing Wall:

a. Material, Galvanized Steel.
b. Factory Finish: Provide G90 galvanized steel.

2. Inside Casing Wall:
a. Material, Galvanized Steel: Solid.
a. Factory Finish: Provide G90 galvanized steel.

E. Floor Plate:

1. Material, Galvanized Steel.
2. Factory Finish: Provide G90 galvanized steel.
3. Materials: injected polyurethane foam insulation.
4. Casing Panel R-Value: Minimum R-13.
5. Insulation Thickness: 2 inches.
6. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

F. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg.
2. For Unit Sections Downstream and Including Fans: 2-inch wg.

G. Panels, Doors, and Windows:

1. Panels:
a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

2. Doors:
a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.

3. Locations and Applications:
a. Fan Section: Panels.
b. Coil Section: Panels.
c. Access Section: Panels.
d. Filter Section: Panels large enough to allow periodic removal and installation of filters.

2.04 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
   a. Turned, ground, and polished hot-rolled steel with keyway.
2. Shaft Bearings:
   a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.
   b. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000 hours according to ABMA 11.
   c. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
   a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
4. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
5. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; [steel] [**aluminum**] hub riveted to backplate and fastened to shaft with setscrews.
6. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; [steel] [aluminum] hub swaged to backplate and fastened to shaft with setscrews.
7. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
8. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices.
9. Shaft Lubrication Lines: Extended to a location outside the casing.
10. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch- wide by 0.028-inch- thick, galvanized-steel sheet.
    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
       1) Fabric Minimum Weight: 26 oz./sq. yd..
       2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
       3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Drive, Direct: Factory-mounted, direct drive.

D. Motors:

1. 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."
2. Mount unit-mounted disconnect switches on exterior of unit.

2.05 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.

2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

B. Heating Coils:

1. Electric Resistance Coils:

2.06 AIR FILTRATION SECTION

A. Particulate air filtration is specified in Section 23 41 00 "Particulate Air Filtration."

2.07 DAMPERS

A. Provided by Temperature Controls Contractor.

2.08 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B 09.

E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a [**3000**] -hour salt-spray test according to ASTM B117.

1. Standards:
   a. ASTM B117 for salt spray.
   b. ASTM D2794 for minimum impact resistance of 100 in-lb.
   c. ASTM B3359 for cross hatch adhesion of 5B.
2. Application: Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

PART 3 - EXECUTION

3.01 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-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.02 INSTALLATION, GENERAL

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. 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.

D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 33 00 "Air Duct Accessories."

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 05 53 "Identification for Electrical Systems."

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.05 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.06 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 air-handling system testing, adjusting, and balancing.

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

3.07 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.08 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Air Leak Test
   a. Seal all openings and dampers at the air handling unit to the pressure class listed below before performing the test.
   b. Test draw through air handling units at -5" static pressure.
   c. The contractor and/or the unit manufacturer may brace the access doors in positive sections of the air handling unit to meet the testing requirements.
   d. Verify each air handling unit on a case by case basis and edit the Leakage Test requirements accordingly.
   e. If half of the air handling unit operates at positive pressure and half at negative pressure the units openings shall be sealed and the unit should be tested as such.
   f. This would apply to an air handling unit with an energy recovery device. A typical draw through air handling unit (majority of the unit is under negative pressure) should be tested as indicated above.
   g. If excessive air leakage is found locate leaks, repair in the area of the leak, seal, and retest.
   h. Leakage rate shall not exceed more that 1% of the total system air quantity when subjected to +/- 5" static pressure.
3. Charge refrigerant coils with refrigerant and test for leaks.
4. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13.16

SECTION 23 73 39

INDOOR, DIRECT-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes indoor, direct-fired heating and ventilating units, including the following components:

1. Casings.
2. Fans, drives, and motors.
3. Air filtration.
4. Dampers.
5. Direct, gas-fired burners.
6. Unit control panel.
7. Controls.

1.03 SUBMITTALS

A. Product Data: For each indoor, direct, gas-fired heating and ventilating unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
   a. Include certified fan-performance curves with system operating conditions indicated.
   b. Include certified fan-sound power ratings.
   c. Include fan construction and accessories.
   d. Include motor ratings, electrical characteristics, and motor accessories.
   e. Include fan-speed controllers.
6. Include filters with performance characteristics.
7. Include direct, gas-fired burners with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each indoor, direct, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Startup service reports.

B. Field quality-control reports.

C. Operation and Maintenance Data: For direct, gas-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.05 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than [**one**] year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than [**five**] years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2.02 MANUFACTURERS

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

1. Cambridge
2. AbsolutAire, Inc.
3. CaptiveAire Systems.
4. Greenheck Fan Corporation.
5. Hastings Industries.
6. Modine Manufacturing Company.
7. REZNOR.
8. Sterling HVAC Products.
9. Trane Inc.
1. Weather-Rite.
2. Or approved equal.

2.03 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. Heating and Ventilating Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

B. Configuration: Horizontal unit with horizontal discharge for suspended installation.

1. Discharge Section, Plenum: Plenum with three way throw.

C. Single-Wall Construction:

1. Material: Galvanized-steel
2. Floorplate: Galvanized steel.
3. Insulation and Adhesive:
   a. Materials: Faced NFPA 90A 1" thick insulation in unit cabinet. Closed cell ½" thick rubber insulation in unit base.

D. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, single- or 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 in fan section doors 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 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
4. Locations and Applications:
   a. Fan Section: Inspection and access panels.
   b. Access Section: Doors.
   c. Gas-Fired Burner Section: Inspection and access panels.
   d. Damper Section: Inspection and access panels.
   e. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.
   f. Mixing Section: Doors.

2.04 FAN, DRIVE, AND MOTOR

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.
   a. Turned, ground, and polished hot-rolled steel with keyway.
2. Shaft Bearings: Heavy-duty, self-aligning, sealed ball or roller bearings with grease fittings.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
4. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices.
5. Shaft Lubrication Lines: Extended to a location outside the casing.

6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch- wide by 0.028-inch- thick, galvanized-steel sheet.
   a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. 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."

2.05 AIR FILTRATION

A. Particulate air filtration is specified in Section 23 41 00 "Particulate Air Filtration."

2.06 DAMPERS

A. Provided by Temperature Controls Contractor.

2.07 DIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners: Stainless steel.

1. Rated Minimum Turndown Ratio: Fully modulating
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. Gas Control Valve: Modulating.
5. Gas Train: Burner shall be furnished with a low voltage, hot surface ignition system; two lubricated manual shut-off valves; electric modulating gas valve with low start fire controls; gas pressure regulator; and temperature modulation controls to provide a complete assembled package.

D. Heat-Exchanger and Drain Pan: Stainless steel.

E. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards.
2. Vent Flow Verification
3. High Limit: Thermal switch or fuse to stop burner.
4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
5. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. 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.
8. Control Transformer: 24 V ac.

2.08 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted remote panel, with engraved plastic cover and the following lights and switches:

1. On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250, Type 4X**.**

2.09 CONTROLS

A. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:
   a. Room temperature.
   b. Discharge-air temperature.
   c. Burner operating.
2. ASHRAE 135.1 BACnet communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.10 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.

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.

3.02 INSTALLATION

A. Equipment Mounting:

1. Install heating and ventilating units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with direct, gas-fired heating and ventilating units.

3.03 PIPING 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. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.04 DUCTWORK CONNECTIONS

A. Connect supply ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for flexible duct connectors.

3.05 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 05 53 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.06 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.07 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 and perform the following:
   a. Inspect for visible damage to burner combustion chamber.
   b. Inspect casing insulation for integrity, moisture content, and adhesion.
   c. Verify that clearances have been provided for servicing.
   d. Verify that controls are connected and operable.
   e. Verify that filters are installed.
   f. Purge gas line.
   g. Inspect and adjust vibration isolators.
   h. Verify bearing lubrication.
   i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   j. Adjust fan belts to proper alignment and tension.

B. 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. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
    a. High-limit heat.
    b. Alarms.
11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.08 ADJUSTING

A. Adjust initial temperature set points.

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

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

3.09 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 23 73 39

SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.02 SUBMITTALS

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

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Warranty: Sample of special warranty.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.04 QUALITY ASSURANCE

A. 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. Units and remote electrically powered components shall contain unit mounted, factory prewired terminal block. Electrical components shall be U.L. tested and U.L. labeled.

B. ARI Compliance:

1. Applicable requirements with ARI Standard 210.
2. Applicable requirements with ARI 365 or ARI 210/240, whichever is applicable for the equipment.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.05 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:
   a. For Compressor: Five year(s) from date of Substantial Completion.
   b. For Parts: One year(s) from date of Substantial Completion.
   c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide a heating and cooling Heat Pump unit or Cooling Only unit with an indoor ceiling or wall mounted fan coil with matched outdoor condensing unit as scheduled.

B. Indoor fan coil units shall be complete with coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, R-410A refrigerant and integral Temperature sensing. Unit shall be furnished with integral wall mounting bracket and mounting hardware.

C. Outdoor condensing unit shall be factory assembled suitable for ground, rooftop, or wall hung mounting. Units shall consist of a compressor, an air cooled coil, propeller type outdoor fan, metering device(s), and control box. Units shall discharge air horizontally or vertically as shown on the drawings.

2.02 MANUFACTURERS

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

1. Daikin
2. Mitsubishi
3. York
4. Or approved equal.

2.03 INDOOR UNITS (3 TONS OR LESS)

A. Wall Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection. Cabinet to have galvanized steel sub-chassis. Unit shall be fully insulated for improved thermal and acoustical performance.
2. Grilles: Unit discharge and inlet grilles shall be constructed of high impact plastic.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and galvanized steel tube sheets. Provide with thermal-expansion valve. Comply with ARI 206/110.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.

c. Enclosure Type: Totally enclosed, fan cooled.
d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
e. Mount unit-mounted disconnect switches on exterior of unit.

6. Air Sweep: Automatic, motor driven.
7. Discharge Louvers: Horizontal and vertical louvers shall be adjustable.
8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. 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.
   b. Single-wall, galvanized -steel or stainless steel sheet.
   c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on either end of pan.
   d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
10. Air Filtration Section:
    a. General Requirements for Air Filtration Section:
       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 lifted out from access plenum.
    b. Cleanable filters:
       1) Factory-fabricated, viscous-coated, flat-panel type.
       2) MERV Rating: As scheduled.
       3) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
11. Efficiency Performance: As scheduled.

B. Ceiling Mounted Cassette, Evaporator-Fan Components:

1. Cabinet: Zinc coated steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection. Cabinet to have galvanized steel sub-chassis. Unit shall be fully insulated for improved thermal and acoustical performance.
2. Grilles: Unit discharge and inlet grilles shall be constructed of high impact plastic. Grilles to have hingers and can be opened to obtain access to the filters, indoor fan motor, and control box.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and galvanized steel tube sheets. Provide with thermal-expansion valve. Comply with ARI 206/110.
   a. Enclosure Type: Totally enclosed, fan cooled.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   c. Mount unit-mounted disconnect switches on exterior of unit.
4. Air Sweep: Automatic, motor driven.
5. Discharge Louvers: Horizontal and vertical louvers shall be adjustable.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:
   a. Fabricated with one 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.
   b. Single-wall, galvanized -steel or stainless steel sheet.
   c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on either end of pan.

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

8. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      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 lifted out from access plenum.
   b. Cleanable filters:
      1) Factory-fabricated, viscous-coated, flat-panel type.
      2) MERV Rating: As scheduled.
      3) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
9. Efficiency Performance: As scheduled.

C. Concealed ducted, evaporator fan components

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
5. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Filters: Permanent, cleanable.
8. Condensate Drain Pans:
   a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
      1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
      2) Depth: A minimum of 2 inches deep.
   b. Single-wall, galvanized-steel sheet.
   c. Double-wall, galvanized-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
   d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
      1) Minimum Connection Size: NPS 1.
   e. Pan-Top Surface Coating: Asphaltic waterproofing compound.
   f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.04 OUTDOOR UNITS (3 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Galvanized steel, finished with baked enamel finish on the inside and outside 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. Unit shall have acoustical lining.
   a. Cabinet shall be capable of withstanding 500 hour salt spray test per Federal Test Standard No. 141 (method 6061).
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 or rotary swing type.
   b. Variable speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Compressor shall be equipped with operating oil charge and motor.
   d. Motor shall be NEMA rated F class, suitable for operation in a refrigerant system.
   e. Refrigerant: R-410A.
   f. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Refrigerant Circuit Components: Service valves, service gage port on compressor suction and discharge lines with brass caps, and accumulator.
4. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
5. Fan: Aluminum-propeller type, directly connected to motor. Discharge horizontally or vertically. Fan blades shall be statically and dynamically balanced.
   a. Provide protective grille over fan.
6. Motor: Totally enclosed, permanently lubricated, class B insulation, with integral thermal-overload protection. Shaft shall have inherent corrosion resistance.
7. Low Ambient Kit: Provide wind baffle and regulate fan motor cycles in response to saturated condensing temperature of the unit. The control shall be capable of starting and operation down to 0 degF ambient air temperature. Installation of the kit shall not require changing of the outdoor fan motor.
8. Mounting: On roof rails or wall mounting kit
9. Controls and Safeties:
   a. A time delay control sequence.
   b. Outdoor fan failure detection.
   c. Compressor motor current and temperature overload protection.
   d. Compressor low and high pressure protection.
10. Electrical: Units shall have single point electrical connection (on each section) with electrical characteristics as specified on Drawings. Furnish unit with manufacturer supplied power and control cable. The Division 26 Contractor shall be responsible to provide power to the outdoor unit and install manufacturer supplied power and control cable.

2.05 ACCESSORIES

A. Controls shall consist of a microprocessor based control system. The unit shall have the following functions at a minimum:

1. An automatic restart after power failure at the same operating conditions as at failure.
2. A timer function to provide a minimum 24 hour timer cycle for system Auto Start/Stop.
3. Temperature sensing controls shall sense return air temperature.
4. Automatic air sweep control to provide on or off activation of air sweep louvers.

5. Dehumidification mode shall provide increased latent removal capability by modulating system operation and set point temperature.
6. Fan only operation to provide room air circulation when no cooling or heating is required.
7. Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit.
8. Evaporator fan speed control shall be user selectable: high, medium, low, or microprocessor controlled automatic operation during all operating modes.
9. Automatic heating to cooling changeover. Control shall include dead band to prevent rapid mode cycling between heating and cooling.
10. A liquid level sensor in the condensate reservoir shall stop cooling operation if the liquid level in the reservoir is too high.

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat shall interface with building automation system. Refer to Section 23 09 93 “Direct Digital Control System for HVAC” for building automation system controls protocol.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

G. Condensate Pump: Pump shall be designed for quiet operation. Pump shall consist of an internal reservoir/sensor assembly. Pump shall be capable of minimum 27” lift.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install units, piping, and accessories in accordance with the manufacturer’s written instructions and recommendations.

C. Maintain adequate service access and airflow clearances for all components as recommended by the manufacturer and as indicated on the Drawings.

D. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

E. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 07 72 00 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Equipment Mounting:

1. Install roof mounted, compressor-condenser components on equipment roof rails Comply with requirements specified in Section 23 05 29 “Hangers and Supports for HVAC Piping and Equipment.”
2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

G. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

H. Charge unit(s) with full oil charge and refrigerant charge based on the entire refrigeration system pipe size and length.

3.02 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. Extend cooling coil condensate drain line from unit condensate connection to nearest clear water waste drain location. Refer to the requirements in Section 23 21 13 “Hydronic Piping” for cooling coil condensate piping.

D. Install pre-charged refrigerant piping in accordance with manufacturers recommendations. Contractor shall coordinate with unit manufacturer to determine final refrigerant line sizing.

E. Install refrigerant piping in accordance with manufacturers recommendations. Contractor shall coordinate with unit manufacturer to determine final refrigerant line sizing. Refer to the requirements in Section 23 23 00 “Refrigerant Piping”.

F. Division 26 Contractor shall provide power wiring to the indoor and outdoor unit.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

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

3.04 START UP

A. Adjust units for maximum operating efficiency, adjust all controls to required final settings and demonstrate that all components are functioning properly.

B. Submit four copies of a written startup report following the initial startup. Include in the report:

1. Work done to the system
2. All readings taken
3. A statement certifying that the refrigeration system(s) are leak free
4. A statement certifying that the unit(s) have been placed in proper running condition as recommended by the manufacturer and as intended in the drawings and specifications.

3.05 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 81 26

SECTION 23 82 39.19

WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.02 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Berko; Marley Engineered Products.
2. INDEECO.
3. Markel Products Company; a subsidiary of TPI Corporation.
4. Marley Engineered Products.
5. QMark; Marley Engineered Products.
6. Or approved equal.

2.02 DESCRIPTION

A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

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. Electrical components and work must be in accordance with National Electrical Code.

D. Electrical heating units shall be rated for voltage and phase specified on Drawing Schedules or within Drawings.

E. Electrical items (except external control thermostats) shall be factory prewired to unit mounted electrical junction boxes and be enclosed within control panel with numbered wiring terminals.

2.03 CABINET

A. Front Panel: Extruded-aluminum bar grille, with removable panels fastened with tamperproof fasteners.

B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

C. Cabinet Enclosure: Steel with finish to match cabinet.

2.04 COIL

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.05 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

B. Motor: Permanently lubricated. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

2.06 CONTROLS

A. Controls: Unit-mounted thermostat.

B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

C. Magnetic contactors for each control step.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. Install wall-mounted 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.

END OF SECTION 23 82 39.19

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SECTION 26 05 00

COMMON WORK REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Related Requirements
2. Project Overview
3. Scope
4. Related Work
5. Reference Standards
6. Regulatory Requirements
7. Quality Assurance
8. Protection of Finished Surfaces
9. Approved Electrical Testing Laboratories
10. Sleeves and Openings
11. Sealing and Fire Stopping
12. Owner Furnished Equipment
13. Work by Owner
14. Provisions for Future Work
15. Intent
16. Omissions
17. Submittals
18. Project/Site Conditions
19. Work Sequence and Scheduling
20. Work by Other Trades
21. Offsite Storage
22. Salvage Materials
23. Certificates and Inspections
24. Operating and Maintenance Data
25. Record Drawings
26. Products:
    a. Access Panels and Doors
    b. Sealing and Fire Stopping
27. Work By Others
    a. Excavation and Backfill
    b. Concrete Work
    c. Cutting and Patching
    d. Building Access
    e. Equipment Access
    f. Coordination
    g. Sleeves and Openings
    h. Agency Training

1.02 RELATED REQUIREMENTS

A. Applicable provisions of Division 1 govern work under this Section.

B. Section 01 91 00 – Commissioning Process

C. Section 07 84 00 – Fire Stopping

1.03 REFERENCE STANDARDS

A. Abbreviations of standards organizations referenced in this, and other sections are as follows:

1. ANSI American National Standards Institute
2. ASTM American Society for Testing and Materials
3. EPA Environmental Protection Agency
4. ETL Electrical Testing Laboratories, Inc.
5. IEEE Institute of Electrical and Electronics Engineers
6. IES Illuminating Engineering Society
7. ISA Instrument Society of America
8. NBS National Bureau of Standards
9. NEC National Electric Code
10. NEMA National Electrical Manufacturers Association
11. NESC National Electrical Safety Code
12. NFPA National Fire Protection Association
13. NRTL Nationally Recognized Testing Laboratory
14. UL Underwriters Laboratories Inc.
15. DSPS Wisconsin Department of Safety and Professional Services

1.04 REGULATORY REQUIREMENTS

A. All work and materials are to conform in every detail to applicable rules and requirements of the Wisconsin State Electrical Code (SPS 316), the National Electrical Code (NFPA 70), other applicable National Fire Protection Association codes, the National Electrical Safety Code, and present manufacturing standards (including NEMA).

B. All Division 26 work shall be done under the direction of a currently licensed State of Wisconsin Master Electrician.

C. All Division 26 work shall comply with SPS 101.862 and SPS 305.40 for electrical wiring integral with pre-manufactured structures.

1.05 QUALITY ASSURANCE

A. 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.

B. Manufacturer references used herein are intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

C. All materials, shall be listed by and shall bear the label of an approved Nationally Recognized Testing Laboratory (NRTL) as identified by the United States Occupational Safety and Health Administration (OSHA), per the OSHA Nationally Recognized Testing Laboratory Program. Where one of the approved electrical testing laboratories has an applicable system listing and label, the entire system, shall be so labeled.

1.06 PROTECTION OF FINISHED SURFACES

A. Furnish one can of touch-up paint for each different color factory finish furnished by the Contractor. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

1.07 APPROVED ELECTRICAL TESTING LABORATORIES

A. The following laboratories are approved for providing electrical product safety testing, listing, and labeling services as required in these specifications:

B. A Nationally Recognized Testing Laboratory (NRTL) as identified by the United States Occupational Safety and Health Administration (OSHA), per the OSHA Nationally Recognized Testing Laboratory Program.

1.08 SLEEVES AND OPENINGS

A. Refer to Division 1, General Requirements, Sleeves and Openings.

1.09 SEALING AND FIRE STOPPING

A. Sealing and fire stopping of sleeves/openings between conduits, cable trays, wireways, troughs, cable bus, busduct, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

1.10 OWNER FURNISHED EQUIPMENT

A. None

1.11 PROVISIONS FOR FUTURE WORK

A. None

1.12 INTENT

A. The Contractor shall furnish and install all the necessary materials, apparatus, and devices to complete the electrical equipment and systems installation herein specified, except such parts as are specifically exempted herein.

B. If an item is either called for in the specifications or shown on the plans, it shall be considered sufficient for the inclusion of said item in this contract. If a conflict exists within the Specifications or exists within the Drawings, the Contractor shall furnish the item, system, or workmanship, which is the highest quality, largest, or most closely fits the owner's requirement (as determined by the Architect/Owner/Engineer). Refer to the General Conditions of the Contract for further clarification.

C. It must be understood that the details and drawings are diagrammatic. The Contractor shall verify all dimensions at the site and be responsible for their accuracy.

D. All sizes as given are minimum except as noted.

E. Materials and labor shall be new (unless noted or stated otherwise), first class, and workmanlike, and shall be subject at all times to the Owner's and/or A/E's inspections, tests, and approval from the commencement until the acceptance of the completed work.

F. Whenever a particular manufacturer's product is named, it is intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

1.13 OMISSIONS

A. No later than ten (10) days before bid opening, the Contractor shall call the attention of the A/E to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.14 SUBMITTALS

A. 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 and/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.

B. On request from the A/E, the successful bidder shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc.

C. 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.

D. The submittals must be approved before fabrication is authorized.

1.15 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 permission of A/E before proceeding.

C. Tools, materials, and equipment shall be confined to areas designated by the A/E and Owner.

1.16 WORK SEQUENCE AND SCHEDULING

A. Install work in phases to accommodate user agency's occupancy requirements. During the construction period coordinate electrical schedule and operations with Owner's Construction Representative.

1.17 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 are 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.

1.18 OFFSITE STORAGE

A. Prior approval by the A/E will be needed. In general, building wire, conduit, fittings, and similar rough-in material will not be accepted for off-site storage. No material will be accepted for off-site storage unless shop drawings for the material have been approved.

1.19 SALVAGE MATERIALS

A. No materials removed from this project shall be reused unless specifically noted otherwise. All materials removed shall become the property of and shall be disposed of by the Contractor.

1.20 CERTIFICATES AND INSPECTIONS

A. Obtain and pay for all required installation inspections, except those provided by the Owner, in accordance with the Wisconsin Administrative Code. Deliver originals of these certificates to the A/E.

B. The Electrical Contractor is responsible for coordination of electrical inspections.

1.21 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

B. In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Manufacturer’s wiring diagrams for electrically powered equipment.

1.22 RECORD DRAWINGS

A. The Contractor shall maintain at least one copy each of the specifications and drawings on the job site at all times.

B. The Contractor shall maintain at least one set of contract drawings on which daily records of changes and deviations from contract shall be recorded. Dimensions and elevations on the record drawings shall locate all buried or concealed piping, conduit, or similar items.

C. The daily record of changes shall be the responsibility of Contractor's field superintendent. No arbitrary mark-ups will be permitted.

D. At completion of the project, the Contractor shall submit the marked-up record drawings to the Architect/Engineer prior to final payment.

PART 2 - PRODUCTS

2.01 ACCESS PANELS AND DOORS

A. Lay-in Ceilings:

1. Removable lay-in ceiling tiles in 2 x 2 foot or 2 x 4-foot configuration provided under other divisions are sufficient; no additional access provisions are required unless specifically indicated.

B. Plaster Walls and Ceilings, Concealed Cavities:

1. 16-gauge frame with not less than a 20-gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers and similar wet areas, concealed hinges, screwdriver operated cam latch for general application, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needing service; minimum size 20” x 30”.

2.02 IDENTIFICATION

A. See Electrical section 26 05 53 – Identification for Electrical Systems.

2.03 SEALING AND FIRE STOPPING

A. Fire and/or Smoke Rated Penetrations:

1. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 “Fire Stopping”.

B. Non-Rated Penetrations:

1. Conduit Penetrations Below Grade:
   a. In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated conduit and the cored opening or water-stop type wall sleeve.
2. Conduit and Cable Tray Penetrations Above Grade:
   a. At through-wall conduit and cable tray penetrations of non-rated interior and exterior walls, and floors, use urethane caulk in annular space between conduit and sleeve, or the core drilled opening.

PART 3 - EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Perform all excavation and backfill work to accomplish indicated electrical systems installation unless noted otherwise.

3.02 CONCRETE WORK

A. The Division 3 Contractor will perform all cast-in-place concrete unless noted otherwise elsewhere. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for the support of electrical equipment.

3.03 CUTTING AND PATCHING

A. Refer to Division 1, General Requirements, Cutting and Patching.

3.04 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.

3.05 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 and reimburse the General Contractor for installation of those access doors.

3.06 COORDINATION

A. The Contractor shall cooperate with other trades 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 to the project, 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 contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

3.07 SLEEVES AND OPENINGS

A. Conduit penetrations in new poured concrete horizontal construction requiring F and T rating: Form opening using hole form or core drill opening. Alternatively provide cast in place fire stopping devices/sleeves.

B. Conduit penetrations in new poured concrete horizontal construction requiring F rating but no T rating: Same as conduit penetrations in new poured concrete construction requiring F and T ratings except that schedule 40 steel pipe sleeves may also be used.

C. Conduit penetrations in new poured concrete horizontal construction that do not require F or T ratings: Provide schedule 40 steel pipe sleeve, form opening using hole form or core drill opening.

D. Conduit penetrations in existing concrete floors: Core drill openings.

E. Where penetrating conduit weight is supported by floor, provide manufactured product or structural bearing collar designed to carry load.

3.08 SEALING AND FIRE STOPPING

A. FIRE AND/OR SMOKE RATED PENETRATIONS:

1. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with section 07 84 00 Fire Stopping.

B. NON-RATED PENETRATIONS:

1. In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the conduit and tighten in place, in accordance with the manufacturer's instructions. Install so that the bolts used to tighten the seal are accessible from the interior of the building or vault.

2. At all interior and exterior walls, through-wall conduit penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the sleeve or cored opening and the conduit is completely blocked.

C. PENETRATIONS SUBJECT TO WATER INTRUSION:

1. For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:
   a. Conduit penetration where steel pipe sleeve is used extend steel sleeve 2” above the floor.
   b. Conduit penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2” above the floor (provided it meets the device’s UL listing).
   c. Conduit penetration where there is no steel sleeve or cast in place fire stopping device/sleeve, provide 2”x 2” x 1/8” galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8”on center. Seal corners water tight with urethane caulk.

2. Floors subject to water intrusion or rooms housing electrical equipment include the following locations:
   a. Restrooms
   b. Janitor Rooms w/ Sinks
   c. Mechanical/Plumbing Equipment Rooms
   d. Vehicle Storage and Parking Ramps
   e. Data/Telecommunications Rooms
   f. Electrical Equipment Rooms
3. Provide waterproof caulk sealant top coating on fire stopping system (or other approved means to protect the fire stopping system from water) in areas subject to wash down such as bus terminal waiting areas and restrooms.

3.09 HOUSEKEEPING AND CLEAN UP

A. 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, this Contractor shall remove all tools, excess material and equipment, etc., from the site.

3.10 AGENCY TRAINING

A. All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 79 00.

END OF SECTION 26 05 00

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SECTION 26 05 04

CLEANING, INSPECTION, AND TESTING OF ELECTRICAL EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work under this section includes the required cleaning, inspection, adjustment, maintenance and testing of electrical equipment, as specified herein. This applies only to new electrical and existing electrical equipment being furnished, modified, worked on or serviced by this contractor for this project.

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

B. Section 01 91 00 – Commissioning Process.

PART 2 - PRODUCTS

2.01 Not Used.

PART 3 - EXECUTION

3.01 General Inspection and Cleaning of all Electrical Equipment

A. Inspect for physical damage and abnormal mechanical and electrical conditions.

B. Any item found to be out of tolerance, or in any other way defective as a result of the required inspection or testing, shall be reported to the engineer. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.

C. Compare equipment nameplate information with the latest single line diagram and report any discrepancies.

D. Verify proper auxiliary device operation and indicators.

E. Check tightness of accessible bolted electrical joints. Use torque wrench method.

F. Make a close examination of equipment and remove any shipping brackets, insulation, packing, etc. that may not have been removed during original installation.

G. Make a close examination of equipment and remove any dirt or other forms of debris that may have collected in existing equipment or in new equipment during installation.

H. Clean All Equipment:

1. Vacuum inside of panelboards, switchboards, switchgear, transformer core and coils, bus ducts, and the exterior of all Communications and Electronic Safety and Security hardware and equipment.
2. Loosen attached particles and vacuum them away.
3. Wipe all insulators with a clean, dry, lint free rag.
4. Clean insulator grooves.
5. Re-vacuum inside surfaces as directed by the Owner's Representative or Engineer.

I. Inspect equipment anchorage.

J. Inspect equipment and bus alignment.

K. Check all heater elements for operation and control.

L. Lubricate nonelectrical equipment per manufacturer's recommendations.

3.02 GROUNDING SYSTEMS

A. Inspect the ground system for adequate termination at all devices.

3.03 DRY TYPE TRANSFORMERS

A. Test and adjust the cooling fans, controls and alarm functions.

B. Vacuum clean the transformer enclosure.

C. Measure secondary voltage phase-to-phase and phase-to-ground after final energization and prior to loading.

D. Verify and/or connect transformer "XO" to ground, load side of "WYE" systems.

3.04 METERING AND INSTRUMENTATION

A. Examine all devices for broken parts, damage and wire connection tightness.

B. Verify the electronic meter is connected properly and displaying proper voltage and power quantities.

C. Inspect nameplate information for compatibility with one-line drawings.

D. Verify the instrument transformer connections with the system requirements.

E. Verify tightness of all bolted connections and assure adequate clearances exist from primary circuits to secondary circuit wiring and to grounds.

F. Verify that all required grounding and shorting connections exist and that those connections make good contact; i.e. sufficient surface area, good cleanliness, and proper pressure.

G. Verify proper primary and secondary fuses and required sizes.

3.05 SWITCHBOARDS (LOW VOLTAGE)

A. Visual and Mechanical Inspection:

1. Inspect for physical, electrical and mechanical conditions. Re-torque all bolted connections.
2. Compare equipment nameplate information with latest single line diagram and report discrepancies.
3. Inspect for proper alignment, anchorage and grounding
4. All doors, panels and sections shall be inspected for paint, dents, scratches, and fit.

B. Vacuum clean the switchboard enclosure.

C. All active components shall be exercised and cleaned where possible.

D. All indicating devices shall be inspected for proper operation.

3.06 PANELBOARDS

A. Torque all the connections per the manufacturers spec. Verify phase wires, color coding, separate neutral and mechanical bonding. Verify circuit breaker operation. Verify the directory.

B. Vacuum clean the panelboard enclosure.

3.07 CABLES

A. 600 Volt cable:

1. Visually inspect cables, lugs, connectors and all other components for physical damage and proper connections.
2. Check all cable connectors for tightness (with a torque wrench) and clearances. Torque test conductor terminations to manufacturer's recommendations.
3. Perform a 1000 Vdc megger test on all secondary cables from the substation transformers to the secondary switchboards and on all switchboard feeders.

3.08 LIGHT FIXTURES

A. Check the bonding and proper lamping. Verify that recessed fixtures are installed with hold down clips. Confirm operation of the fixture with the proper switch or sensor.

3.09 OCCUPANCY SENSORS

A. Confirm operation of the sensor per the manufacturer’s specification.

3.10 GENERATORS

A. Run the generator through the standard tests as recommended by the manufacturer including the load bank test. Test the automatic start circuits and run the full diagnostic tests. Check for fuel and coolant leaks.

B. Provide full load testing utilizing a portable test bank for four hours continuous, minimum. During the first two hours, step increase the load from 0% to 100% in at least six equal steps. At the end of two hours, continue running test at 100% load. Record the following in 20 minute intervals throughout the four hour test: kilowatts, amperes, voltage, coolant temperature, room temperature, generator frequency (Hz), oil pressure, fuel consumption.

C. After the generator has cooled down from the four-hour test, shut it down and then simulate a power failure including operation of the transfer switch, automatic cycle, and automatic shutdown and return to normal.

3.11 AUTOMATIC TRANSFER SWITCHES

A. Coordinate with the generator and the subsequent tests.

B. Check the automatic transfer switches and automatic start circuits for proper function.

3.12 COMMUNICATIONS AND ELECTRONIC SAFETY AND SECURITY

A. At equipment rooms:

1. Check all cable and connectors for proper installation and support.
2. Visually inspect cables, lugs, connectors and all other components for physical damage and proper connections.
3. Confirm cable bends to comply with manufacturer's minimum allowable bending radii.
4. Inspect for proper shield grounding, cable support and termination.
5. Confirm all dust caps and blank panels are in place.

B. Wipe down all equipment racks and cabinets, enclosures, cable supports, cable organizers, termination hardware and related items.

C. Coordinate cleaning schedule to provide a secure, dust and contaminant-free environment as required to accommodate all trade’s equipment that will be positioned in the room. This condition likely will precede general occupancy.

D. Refer to Division 27 and 28 specification sections that may include additional requirements.

END OF SEC0TION 26 05 04

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Aluminum building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Fire-alarm wire and cable.
5. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 26 05 23 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
3. Section 27 00 05 "Communications Cabling" for cabling used for voice and data circuits.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

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

1. Belden; brand of Belden, Inc.
2. Cerro Wire LLC.
3. General Cable; Prysmian Group North America.
4. Southwire Company, LLC.
5. Or approved equal.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Aluminum, complying with ASTM B800.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

2.3 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

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

1. Belden; brand of Belden, Inc.
2. General Cable; Prysmian Group North America.
3. Southwire Company, LLC.
4. Or approved equal.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

1. Single circuit.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors

F. Ground Conductor: Insulated.

G. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

H. Armor: Steel , interlocked.

2.4 FIRE-ALARM WIRE AND CABLE

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

1. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Genesis Cable Products; Honeywell International, Inc.
5. Or approved equal.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
2. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

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

1. 3M Electrical Products.
2. ABB, Electrification Business.
3. AFC Cable Systems; Atkore International.
4. Hubbell Utility Solutions; Hubbell Incorporated.
5. NSi Industries LLC.
6. Service Wire Co.
7. Or approved equal.

C. Jacketed Cable Connectors: For steel jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: One hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper; stranded for No. 12 AWG and larger.

B. Branch Circuits:

1. Copper, stranded for No. 12 AWG and larger.

C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-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, and Underground: Type XHHW-2, single conductors in raceway.

D. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway Metal-clad cable, Type MC

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 26 05 29 "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 6 inch 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 Section 07 84 13 "Penetration Firestopping."

END OF SECTION 26 05 19

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SECTION 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. Category 5e balanced twisted pair cable.
3. Balanced twisted pair cabling hardware.
4. Control cabling.
5. Control-circuit conductors.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 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.

B. 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 inch or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. 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.

2.2 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inch. Comply with requirements for plywood backing panels in Section 06 10 00 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat white latex paint. Comply with requirements in Section 09 91 23 "Interior Painting."

2.3 CATEGORY 5e BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz

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

1. AMP NETCONNECT; a TE Connectivity Ltd. company.
2. Belden Inc.
3. Berk-Tek Leviton; a Nexans/Leviton alliance.
4. CommScope, Inc.
5. General Cable; Prysmian Group North America.
6. Mohawk Cable; brand of Belden, Inc.
7. Or Approved Equal

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

D. Conductors: 100-ohm, No. 24 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP) .

F. Cable Rating: Plenum.

G. Jacket: White thermoplastic.

2.4 CONTROL CABLE

A. 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.

2.5 CONTROL-CIRCUIT CONDUCTORS

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

1. Encore Wire Corporation.
2. General Cable; Prysmian Group North America.
3. Southwire Company, LLC.
4. Or approved equal

B. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

2.6 FIRE-ALARM WIRE AND CABLE

A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

1. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

B. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Control-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Low-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 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 must be no smaller than 4-inch square by 2-1/8 inch deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
2. Flexible metal conduit must not be used.

B. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. 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 inch above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

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."
3. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inch and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. 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." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lay on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 27 15 13 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. 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."

E. 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 inch above ceilings by cable supports not more than 30 inches apart.
3. Cable must 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.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. 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 Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.6 GROUNDING

A. For control-voltage 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."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

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:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connector.
7. Grounding and bonding busbars.
8. Grounding (earthing) electrodes.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data:

1. For each type of product indicated.

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2, copper wire or cable, green color, in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ERICO; brand of nVent Electrical plc.
   b. Harger Lightning & Grounding; business of Harger, Inc.
   c. Or approved equal
2. Referenced Standards: Complying with one or more of the following:
   a. Soft or Annealed Copper Wire: ASTM B3
   b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
   c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
   d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

2.2 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications; see Section 27 05 26 "Grounding and Bonding for Communications Systems," for selection and installation guidelines.

B. Performance Criteria:

1. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
   b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Cooper B-line; brand of Eaton, Electrical Sector.
   c. Crouse-Hinds; brand of Eaton, Electrical Sector.
   d. ERICO; brand of nVent Electrical plc.
   e. Galvan Industries, Inc.; Electrical Products Division, LLC.
   f. Panduit Corp.
   g. Or approved equal
2. General Characteristics:
   a. Two pieces with zinc-plated bolts.
   b. Clamp Material: Corrosion-resistant copper alloy.
   c. Listed for outdoor use.

D. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Cooper B-line; brand of Eaton, Electrical Sector.
   c. Crouse-Hinds; brand of Eaton, Electrical Sector.
   d. ERICO; brand of nVent Electrical plc.
   e. Galvan Industries, Inc.; Electrical Products Division, LLC.
   f. Panduit Corp.
   g. Or approved equal
2. General Characteristics:
   a. Clamp Material: Bronze.
   b. Listed for outdoor use.

E. UL KDER - Beam Grounding and Bonding Clamp :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Anderson; brand of Hubbell Utility Solutions; Hubbell Incorporated.

c. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Panduit Corp.
e. Penn-Union Corp.; subsidiary of Nesco, Inc.
f. Or approved equal

2. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

F. UL KDER - Exothermically Welded Connection :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. ERICO; brand of nVent Electrical plc.
e. Or approved equal

2. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING AND BONDING BUSHINGS

A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.

B. Performance Criteria:

1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Bonding Bushing :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Or approved equal

2. General Characteristics: Threaded bushing with insulated throat.

D. UL KDER - Grounding Bushing :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Or approved equal

2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.4 GROUNDING AND BONDING HUBS

A. Description: Hubs with certified grounding or bonding locknut.

B. Performance Criteria:

1. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Grounding and Bonding Hub :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Arlington Industries, Inc.
   c. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   d. Crouse-Hinds; brand of Eaton, Electrical Sector.
   e. Penn-Union Corp.; subsidiary of Nesco, Inc.
   f. Or approved equal
2. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.5 GROUNDING AND BONDING CONNECTORS

A. Performance Criteria:

1. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
   b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

B. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Or approved equal
2. General Characteristics: Mechanical-type, copper rated for direct burial terminal with set screw.

2.6 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.

B. Performance Criteria:

1. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
   a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Galvan Industries, Inc.; Electrical Products Division, LLC.
   b. Madison Electric Products; business of Southwire Company, LLC.
   c. Or approved equal
2. General Characteristics: Zinc-alloy one-piece construction; six terminating points; gangable.

2.7 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding device that serves as common connection for multiple grounding and bonding conductors.

B. Performance Criteria:

1. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Equipment Room Grounding and Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   b. Chatsworth Products, Inc.
   c. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
   d. Cooper B-line; brand of Eaton, Electrical Sector.
   e. ERICO; brand of nVent Electrical plc.
   f. Harger Lightning & Grounding; business of Harger, Inc.
   g. Hoffman; brand of nVent Electrical plc.
   h. ILSCO.
   i. Panduit Corp.
   j. Or approved equal
2. General Characteristics:

a. Bus: Rectangular bar of annealed copper.
b. Mounting Stand-Off Insulators: Lexan or PVC.
1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.

3. Options:
a. Predrilled Hole Pattern: Suitable for installing specified grounding and bonding connectors.
b. Mounting Hardware: Stand-off brackets that provide 2 inch clearance to access rear of bus. Brackets and bolts must be stainless steel.

2.8 GROUNDING (EARTHING) ELECTRODES

A. Description: Grounding electrodes include rod electrodes, ring electrodes, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes.

B. Performance Criteria:

1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Rod Electrode :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. allG Fabrication; business of Advanced Lightning Technology, Ltd.
c. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
d. ERICO; brand of nVent Electrical plc.
e. Galvan Industries, Inc.; Electrical Products Division, LLC.
f. Harger Lightning & Grounding; business of Harger, Inc.
g. Or approved equal
2. General Characteristics: Copper-clad steel; 3/4 inch by 10 ft .

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF BUSBARS

A. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.3 SELECTION OF GROUNDING AND BONDING CONDUCTORS

A. Conductors: Install solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.

B. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.

C. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.

D. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.

E. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

F. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

G. Underground Grounding Conductors: Install bare copper conductor, 2/0 AWG minimum.

1. Bury at least 30 inch below grade.

3.4 SELECTION OF CONNECTORS

A. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.5 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Conductors:
   a. 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.

2. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   b. Make connections with clean, bare metal at points of contact.
   c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
   d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
   f. 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 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 disconnect-type connection is required, use bolted clamp.
   g. Grounding and Bonding for Piping:
      1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
      2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
3. Electrodes:
   a. Ground Rods: Drive rods until tops are 2 inch below finished floor or final grade unless otherwise indicated.
      1) Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
      2) Use exothermic welds for below-grade connections.
   b. For grounding electrode system, install at least two rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.
   c. Concrete-Encased Electrode (Ufer Ground):
      1) Fabricate in accordance with NFPA 70; use minimum of 20 ft of bare copper conductor not smaller than 4 AWG .
         a) If concrete foundation is less than 20 ft long, coil excess conductor within base of foundation.
         b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
      2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

4. Grounding at Service:
   a. Equipment grounding conductors and grounding electrode conductors must be connected to ground bus. Install main bonding jumper between neutral and ground buses.
5. Grounding Underground Distribution System Components:
   a. Comply with IEEE C2 grounding requirements.
6. Equipment Grounding:
   a. Install insulated equipment grounding conductors with 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 separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
   d. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

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 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Structural steel for fabricated supports and restraints.
4. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
5. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Allied Tube & Conduit; Atkore International.
   c. Cooper B-line; brand of Eaton, Electrical Sector.
   d. Unistrut; Atkore International.
   e. Or approved equal.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Plain steel .

4. Channel Width: 1-5/8 inch .
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

D. 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 where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-line; brand of Eaton, Electrical Sector.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) MKT Fastening, LLC.
      5) Or approved equal
2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
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.

B. Materials: Comply with requirements in Section 05 50 00 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA NEIS 101

B. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceway and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.

E. 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 two-bolt conduit clamps .

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF SUPPORTS

A. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT may be supported by openings through structure members, in accordance with NFPA 70.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69 .
5. To Light Steel: Sheet metal screws.
6. 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.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 50 00 "Metal Fabrications" for site-fabricated metal supports.

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

END OF SECTION 26 05 29

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SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT-S raceways and elbows.
2. Type ERMC-S raceways, elbows, couplings, and nipples.
3. Type IMC raceways.
4. Type LFMC raceways.
5. Type PVC raceways and fittings.
6. Fittings for conduit, tubing, and cable.
7. Solvent cements.
8. Surface metal raceways and fittings.
9. Wireways and auxiliary gutters.
10. Metallic outlet boxes, device boxes, rings, and covers.
11. Nonmetallic outlet boxes, device boxes, rings, and covers.
12. Termination boxes.
13. Cabinets, cutout boxes, junction boxes, and pull boxes.
14. Cover plates for device boxes.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Wireways and auxiliary gutters.
2. Surface metal raceways.
3. Floor boxes.
4. Cabinets and cutout boxes.

B. Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details. Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

PART 2 - PRODUCTS

2.1 TYPE EMT-S RACEWAYS AND ELBOWS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 797 and UL Category Control Number FJMX.

B. Steel Electrical Metal Tubing (EMT-S) and Elbows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit; Atkore International.
   b. Calconduit; Atkore International.
   c. Emerson Electric Co.
   d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
   e. Topaz Lighting & Electric.
   f. Western Tube; Zekelman Industries.
   g. Wheatland Tube; Zekelman Industries.
   h. ABB, Electrification Business.
   i. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   j. Erickson Electrical Equipment Company.
   k. Hoffman; brand of nVent Electrical plc.
   l. Or approved equal
2. Material: Steel.
3. Options:
   a. Exterior Coating: Zinc .
   b. Interior Coating: Zinc with organic top coating .
   c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   d. Colors: As indicated on Drawings.

2.2 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL Category Control Number DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit; Atkore International.
   b. Calconduit; Atkore International.
   c. Crouse-Hinds; brand of Eaton, Electrical Sector.
   d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
   e. Topaz Lighting & Electric.
   f. Western Tube; Zekelman Industries.
   g. Wheatland Tube; Zekelman Industries.
   h. Or approved equal
2. Exterior Coating: Zinc.
3. Options:
   a. Interior Coating: Zinc with organic top coating.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   c. Colors: As indicated on Drawings.

2.3 TYPE IMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

2. General Characteristics: UL 1242 and UL Category Control Number DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Allied Tube & Conduit; Atkore International.
   c. Calconduit; Atkore International.
   d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
   e. Topaz Lighting & Electric.
   f. Western Tube; Zekelman Industries.
   g. Wheatland Tube; Zekelman Industries.
   h. Or approved equal
2. Options:
   a. Exterior Coating: Zinc .
   b. Interior Coating: Zinc with organic top coating .
   c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   d. Colors: As indicated on Drawings.

2.4 TYPE LFMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 360 and UL Category Control Number DXHR.

B. Steel Liquidtight Flexible Metal Conduit (LFMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Anaconda Sealtite; Anamet Electrical, Inc.
   c. Electri-Flex Company.
   d. International Metal Hose Co.
   e. Or approved equal
2. Material: Steel.
3. Options:
   a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   b. Colors: As indicated on Drawings.

2.5 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651 and UL Category Control Number DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

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

b. Calconduit; Atkore International.
c. JM Eagle; J-M Manufacturing Co., Inc.
d. NAPCO; Westlake Chemical Corp.
e. Opti-Com Manufacturing Network, Inc (OMNI).
f. Topaz Lighting & Electric.
g. Or approved equal

2. Dimensional Specifications: Schedule 40.
3. Options:
   a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   b. Markings: For use with maximum 90 deg C wire.

C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Calconduit; Atkore International.
   c. JM Eagle; J-M Manufacturing Co., Inc.
   d. Opti-Com Manufacturing Network, Inc (OMNI).
   e. Topaz Lighting & Electric.
   f. Or approved equal
2. Dimensional Specifications: Schedule 80.
3. Options:
   a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   b. Markings: For use with maximum 90 deg C wire.

2.6 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Fittings for Type ERMC, Type IMC, and Type PVC Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   f. Southwire Company, LLC.
   g. Topaz Lighting & Electric.
   h. Or approved equal
2. General Characteristics: UL 514B and UL Category Control Number DWTT.
3. Options:
   a. Material: Steel .
   b. Coupling Method: Raintight compression coupling with distinctive color gland nut .
   c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
   d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

C. Fittings for Type EMT Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Allied Tube & Conduit; Atkore International.
   c. Calconduit; Atkore International.
   d. Crouse-Hinds; brand of Eaton, Electrical Sector.
   e. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   h. Southwire Company, LLC.
   i. Topaz Lighting & Electric.
   j. Or approved equal
2. General Characteristics: UL 514B and UL Category Control Number FKAV.
3. Options:
   a. Material: Steel .
   b. Coupling Method: Compression coupling .
   c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
   d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

D. Fittings for Type LFMC Raceways:

1. Manufacturers: Subject to compliance with requirements, undefined:
   a. Liquid Tight Connector Co.
   b. Or approved equal
2. General Characteristics: UL 514B and UL Category Control Number DXAS.

2.7 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL Category Control Number DWTT.

2.8 SURFACE METAL RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 5 and UL Category Control Number RJBT.

B. Surface Metal Raceways and Fittings with Metal Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   b. MonoSystems, Inc.
   c. Wiremold; Legrand North America, LLC.
   d. Or approved equal
2. Options:
   a. Galvanized steel base with snap-on covers.

b. Manufacturer's standard enamel finish in color selected by Architect .
c. Wiring Channels: Dual . Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

2.9 WIREWAYS AND AUXILIARY GUTTERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 870 and UL Category Control Number ZOYX.

B. Metal Wireways and Auxiliary Gutters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Cooper B-line; brand of Eaton, Electrical Sector.
   c. Hoffman; brand of nVent Electrical plc.
   d. MonoSystems, Inc.
   e. Square D; Schneider Electric USA.
   f. Wiegmann; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   g. Or approved equal
2. Additional Characteristics:
   a. 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.
   b. Finish: Manufacturer's standard enamel finish.
3. Options:
   a. Degree of Protection: Type 1 unless otherwise indicated.
   b. Wireway Covers: Screw-cover type unless otherwise indicated.

2.10 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 514A and UL Category Control Number QCIT.

B. Metallic Outlet Boxes:

1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
g. Pass & Seymour; Legrand North America, LLC.
h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
i. Topaz Lighting & Electric.
j. Wiremold; Legrand North America, LLC.
k. Or approved equal

3. Options:
   a. Material: Sheet steel .
   b. Sheet Metal Depth: Minimum 2.5 inch.
   c. Cast-Metal Depth: Minimum 2.4 inch.
   d. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing more than 50 lb and marked with maximum allowable weight.
   e. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb.

C. Metallic Conduit Bodies:

1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   e. Pass & Seymour; Legrand North America, LLC.
   f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   g. Topaz Lighting & Electric.
   h. Or approved equal

D. Metallic Device Boxes:

1. Description: Box with provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   h. Topaz Lighting & Electric.
   i. Or approved equal
3. Options:
   a. Material: Sheet steel.
   b. Sheet Metal Depth: minimum 2.5 inch.
   c. Cast-Metal Depth: minimum 2.4 inch.

E. Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. FSR Inc.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Wiremold; Legrand North America, LLC.
   d. Or approved equal

F. Metallic Concrete Boxes and Covers:

1. Description: Box intended for use in poured concrete.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   d. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   e. Topaz Lighting & Electric.
   f. Wiremold; Legrand North America, LLC.
   g. Or approved equal

2.11 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 514C and UL Category Control Number QCMZ.

B. Nonmetallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Allied Tube & Conduit; Atkore International.
   c. Arlington Industries, Inc.
   d. Cantex Inc.
   e. JM Eagle; J-M Manufacturing Co., Inc.
   f. Pass & Seymour; Legrand North America, LLC.
   g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   h. Wiremold; Legrand North America, LLC.
   i. Or approved equal

2.12 CABINETS, CUTOUT BOXES, JUNCTION BOXES, AND PULL BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
   a. Non-Environmental Characteristics: UL 50.
   b. Environmental Characteristics: UL 50E.

B. Indoor Sheet Metal Cabinets:

1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Adalet.
   c. Crouse-Hinds; brand of Eaton, Electrical Sector.
   d. Erickson Electrical Equipment Company.
   e. FSR Inc.
   f. Hoffman; brand of nVent Electrical plc.
   g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   h. Robroy Enclosures; Robroy Industries.
   i. Or approved equal
3. Additional Characteristics: UL Category Control Number CYIV.
4. Options:
   a. Degree of Protection: Type 1.

C. Indoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adalet.
   b. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   c. FSR Inc.
   d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   g. Or approved equal
3. Additional Characteristics: UL Category Control Number BGUZ.
4. Options:
   a. Degree of Protection: Type 1.

D. Indoor Cast-Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adalet.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

e. Or approved equal

3. Additional Characteristics: UL Category Control Number BGUZ.

4. Options:

a. Degree of Protection: Type 1.

E. Outdoor Sheet Metal Cabinets:

1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.

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

a. ABB, Electrification Business.
b. Adalet.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Erickson Electrical Equipment Company.
e. FSR Inc.
f. Hoffman; brand of nVent Electrical plc.
g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
h. Robroy Enclosures; Robroy Industries.
i. Or approved equal

3. Additional Characteristics: UL Category Control Number CYIV.

a. Options:

b. Degree of Protection: Type 3R.

F. Outdoor Cast-Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.

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

a. Adalet.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
e. Or approved equal

3. Additional Characteristics: UL Category Control Number BGUZ.

4. Options:

a. Degree of Protection: Type 3R.

G. Outdoor Polymeric Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.

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

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. JM Eagle; J-M Manufacturing Co., Inc.
e. Robroy Enclosures; Robroy Industries.
f. Topaz Lighting & Electric.
g. Or approved equal

3. Additional Characteristics: UL Category Control Number BGUZ.

4. Options:
   a. Degree of Protection: Type 3R.

2.13 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
   a. Reference Standards: UL 514D and UL Category Control Numbers QCIT and QCMZ.
   b. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Metallic Cover Plates for Device Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. EGS; Emerson Electric Co., Automation Solutions, Appleton Group.
   d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   g. Panduit Corp.
   h. Pass & Seymour; Legrand North America, LLC.
   i. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   j. Topaz Lighting & Electric.
   k. Wiremold; Legrand North America, LLC.
   l. Or approved equal
2. Options:
   a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.

PART 3 - EXECUTION

3.1 SELECTION OF RACEWAYS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.

B. Outdoors:

1. Exposed and Subject to Physical Damage: ERMC, IMC .
   a. Locations less than 2.5 m above finished floor.
2. Exposed and Not Subject to Physical Damage: ERMC, IMC, PVC-80.
3. Concealed Aboveground: ERMC, IMC, EMT .
4. Direct Buried: PVC-80, PVC-40.
5. Parking garage risers: ERMC
   a. Horizontal exposed runs under parking deck: IMC, PVC-80.

C. Indoors:

1. Exposed and Subject to Physical Damage: ERMC IMC . Subject to physical damage includes the following locations:
   a. Locations less than 2.5 m above finished floor.
   b. Stub-ups to above suspended ceilings.
2. Exposed and Not Subject to Physical Damage: ERMC IMC EMT .
3. Concealed in Ceilings and Interior Walls and Partitions: ERMC IMC EMT .
4. Damp or Wet Locations: ERMC IMC Corrosion-resistant EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC .

D. Raceway Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.

1. ERMC and IMC: Provide threaded type fittings unless otherwise indicated.

3.2 SELECTION OF BOXES AND ENCLOSURES

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:
   a. Type 3R unless otherwise indicated.
   b. Locations Exposed to Hosedown: Type 4.
2. Indoors:
   a. Type 1 unless otherwise indicated.

C. Exposed Boxes Installed Less Than 2.5 m Above Floor:

1. Boxes with knockouts or unprotected openings are prohibited.
2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.3 INSTALLATION OF RACEWAYS

A. Installation Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for installation of raceways. Consult Architect for resolution of conflicting requirements.
2. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
3. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports.
4. Comply with NECA NEIS 101 for installation of steel raceways.
5. Comply with NECA NEIS 102 for installation of aluminum raceways.
6. Comply with NECA NEIS 111 for installation of nonmetallic raceways.
7. Install raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
8. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-

1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

9. Raceway Terminations at Locations Subject to Moisture or Vibration:
   a. Provide insulating bushings to protect conductors, including conductors smaller than No. 4 AWG. Install insulated throat metal grounding bushings on service conduits.

B. General Requirements for Installation of Raceways:

1. Complete raceway installation before starting conductor installation.
2. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
3. Install no more than equivalent of three 90-degree bends in conduit run. Support within 12 inch of changes in direction.
4. Make bends in raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
5. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
6. Support conduit within 12 inches of enclosures to which attached.
7. Install raceway sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings in accordance with NFPA 70.
8. 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 interior of raceways at the following points:
   a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   b. Where an underground service raceway enters a building or structure.
   c. Conduit extending from interior to exterior of building.
   d. Conduit extending into pressurized duct and equipment.
   e. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
   f. Where otherwise required by NFPA 70.
9. Do not install conduits within 2 inches of the bottom side of a metal deck roof.
10. 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.
11. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
12. Install pull wires in empty raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inches of slack at both ends of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

C. Requirements for Installation of Specific Raceway Types:

1. Types ERMC and IMC:
   a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

2. Type ERMC-S-PVC:
   a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
   b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMC-S-PVC elbows in direct-burial applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMC-S-PVC raceway.
   c. Coat field-cut threads on PVC-coated raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.
3. Types FMC and LFMC:
   a. Comply with NEMA RV 3. Provide 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.
4. Type PVC:
   a. Do not install Type PVC conduit where ambient temperature exceeds 122 deg F . Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
   b. Comply with manufacturer's written instructions for solvent welding and fittings.

D. Stub-ups to Above Recessed Ceilings:

1. Provide EMT, IMC, or ERMC for raceways.
2. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

E. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

1. ERMC-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
2. EMT: Provide compression, fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

F. Expansion-Joint Fittings:

1. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
2. Install type and quantity of fittings that accommodate temperature change listed for 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.
   d. Attics: 135 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 locations where conduits cross building or structure expansion joints.

5. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

G. Raceways Penetrating Rooms or Walls with Acoustical Requirements:

1. Seal raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

3.4 INSTALLATION OF SURFACE RACEWAYS

A. Install surface raceways only where indicated on Drawings.

B. Install surface raceway with a minimum 2-inch radius control at bend points.

C. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's written instructions. Tape and glue are unacceptable support methods.

3.5 INSTALLATION OF BOXES AND ENCLOSURES

A. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.

B. 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.

C. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.

D. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

E. Locate boxes so that cover or plate will not span different building finishes.

F. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.

G. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.

H. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.

I. Set metal floor boxes level and flush with finished floor surface.

J. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

K. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.

L. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:

1. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
2. Provide gaskets for wallplates and covers.

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.7 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.

3.8 CLEANING

A. Boxes: Remove construction dust and debris from device boxes, outlet boxes, and floor-mounted enclosures before installing wallplates, covers, and hoods.

END OF SECTION 26 05 33

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Tapes and stencils.
3. Signs.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 1000 V or Less:

1. Black letters on orange field .
2. Legend: Indicate voltage.

B. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

1. Color must be factory applied or field applied for sizes larger than 8 AWG if authorities having jurisdiction permit.
2. Colors for 208Y/120 V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
3. Colors for 480Y/277 V Circuits:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
4. Color for Neutral: White or gray.
5. Color for Equipment Grounds: Green .
6. Colors for Isolated Grounds: Green with two or more yellow stripes.

C. Warning Label Colors:

1. Identify system voltage with black letters on orange background.

D. Warning labels and signs must 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 3 FEET MINIMUM."

E. Equipment Identification Labels:

1. Black letters on white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Champion America.
   c. HellermannTyton.
   d. Marking Services, Inc.
   e. Panduit Corp.
   f. Seton Identification Products; a Brady Corporation company.
   g. Or approved equal

B. Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A'n D Cable Products.
   b. Brady Corporation.
   c. Brother International Corporation.
   d. Ideal Industries, Inc.
   e. Marking Services, Inc.

f. Panduit Corp.
g. Seton Identification Products; a Brady Corporation company.
h. Or approved equal

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over legend. Labels sized such that clear shield overlaps entire printed legend.
3. Marker for Labels:
   a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
   b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

C. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A'n D Cable Products.
   b. Brady Corporation.
   c. Brother International Corporation.
   d. HellermannTyton.
   e. Ideal Industries, Inc.
   f. Marking Services, Inc.
   g. Panduit Corp.
   h. Seton Identification Products; a Brady Corporation company.
   i. Or approved equal
2. Minimum Nominal Size:
   a. 1-1/2 by 6 inch for raceway and conductors.
   b. 3-1/2 by 5 inch for equipment.
   c. As required by authorities having jurisdiction.

2.4 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Carlton Industries, LP.
   b. Champion America.
   c. HellermannTyton.
   d. Ideal Industries, Inc.
   e. Marking Services, Inc.
   f. Panduit Corp.
   g. Or approved equal

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil thick by 1 to 2 inch wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. Marking Services, Inc.
   d. Or approved equal

C. Underground-Line Warning Tape:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Ideal Industries, Inc.
   c. Marking Services, Inc.
   d. Seton Identification Products; a Brady Corporation company.
   e. Or approved equal
2. Tape:
   a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape must be permanent and may not be damaged by burial operations.
   c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Color and Printing:
   a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
   b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW" .
   c. Inscriptions for Orange Tapes: "CAUTION BURIED COMMUNICATION LINE BELOW" .
4. Tape Properties :
   a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
   b. Width: 3 inch.
   c. Overall Thickness: 5 mil.
   d. Foil Core Thickness: 0.35 mil.
   e. Weight: 28 lb/1000 sq. ft.
   f. Tensile in accordance with ASTM D882: 70 lbf and 4600 psi.

2.5 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. Marking Services, Inc.
   d. Seton Identification Products; a Brady Corporation company.
   e. Or approved equal
2. Engraved legend.
3. Thickness:
   a. For signs up to 20 sq. inch, minimum 1/16 inch thick.
   b. For signs larger than 20 sq. inch, 1/8 inch thick.
   c. Engraved legend with black letters on white face.
   d. Self-adhesive.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

I. Emergency Operating Instruction Signs: Install instruction signs with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

K. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:

1. "EMERGENCY POWER."
2. "POWER."

L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

M. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

N. Self-Adhesive Labels:

1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide 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 inch high.

O. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

P. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

Q. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inch below finished grade. Use multiple tapes where width of multiple lines installed in common trench or concrete envelope exceeds 16 inch overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

R. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high sign; where two lines of text are required, use labels 2 inch high.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels .

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

D. Power-Circuit Conductor Identification, 1000 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels self-adhesive wraparound labels self-adhesive vinyl tape to identify phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

E. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels .

1. Apply to exterior of door, cover, or other access.
2. 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.

G. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign .

END OF SECTION 26 05 53

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SECTION 26 05 73

SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, fault-current study to determine minimum interrupting capacity of circuit protective devices.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 26 05 74 "Coordination Studies" for overcurrent protective device coordination studies.
3. Section 26 05 75 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 SUBMITTALS

A. Short-Circuit Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.
   a. Short-circuit study input data, including completed computer program input data sheets.
   b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
   c. Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.3 QUALITY ASSURANCE

A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

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

1. EasyPower, LLC (formerly ESA Inc.).
2. ETAP - Digital Twin Platform.
3. SKM Systems Analysis, Inc.
4. Or approved equal

B. Analytical features of power systems analysis software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
6. Derating factors and environmental conditions.
7. Any revisions to electrical equipment required by study.

D. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.

b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Equivalent impedance.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

A. Obtain data necessary for conduct of study.

B. Gather and tabulate required input data to support short-circuit study. Comply with requirements in Section 01 78 39 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

3.2 SHORT-CIRCUIT STUDY

A. Perform study following general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on device characteristics supplied by device manufacturer.

D. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.
2. Exclude equipment supplied by single transformer smaller than 75 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

G. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

H. Include in report identification of protective device applied outside its capacity.

END OF SECTION 26 05 73

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SECTION 26 05 74

COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 26 05 73 "Short-Circuit Studies" for fault-current studies.
3. Section 26 05 75 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 SUBMITTALS

A. Coordination Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.
   a. Coordination-study input data, including completed computer program input data sheets.
   b. Study and equipment evaluation reports.
   c. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
   d. Revised one-line diagram, reflecting field investigation results and results of coordination study.

1.3 QUALITY ASSURANCE

A. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

1.4 REGULATORY AGENCY APPROVALS

A. Submittals for coordination study requiring approval by authorities having jurisdiction must be signed and sealed by qualified electrical professional engineer responsible for their preparation. Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

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

1. EasyPower, LLC (formerly ESA Inc.).
2. ETAP - Digital Twin Platform.
3. SKM Systems Analysis, Inc.
4. Or approved equal

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 COORDINATION STUDY REPORT CONTENTS

A. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Revisions to electrical equipment required by study.
7. Study Input Data: As described in "Power System Data" Article.
    a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 73 "Short-Circuit Studies."

B. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.
    a. Circuit Breakers:
        1) Adjustable pickups and time delays (long time, short time, and ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.
    b. Fuses: Show current rating, voltage, and class.

C. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying portion of system covered.
2. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
    a. Power utility's overcurrent protective device.
    b. Medium-voltage equipment overcurrent relays.
    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f. Cables and conductors damage curves.
    g. Ground-fault protective devices.
    h. Motor-starting characteristics and motor damage points.
    i. Generator short-circuit decrement curve and generator damage point.
    j. Largest feeder circuit breaker in each motor-control center and panelboard.
5. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device must not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings must protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.

K. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Include in report identification of protective device applied outside its capacity.

3.3 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

END OF SECTION 26 05 74

SECTION 26 05 75

ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, arc-flash study to determine arc-flash hazard distance and incident energy to which personnel could be exposed during work on or near electrical equipment.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 26 05 73 "Short-Circuit Studies" for fault-current studies.
3. Section 26 05 74 "Coordination Studies" for overcurrent protective device coordination studies.

1.2 DEFINITIONS

A. p.u.: Per unit. The reference unit, established as a calculating convenience, for expressing all power system electrical parameters on a common reference base.

1.3 SUBMITTALS

A. Arc Flash Hazard Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form:
   a. Arc-flash study input data, including completed computer program input data sheets.
   b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
   c. Revised one-line diagram, reflecting field investigation results and results of arc-flash study.

1.4 QUALITY ASSURANCE

A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Manual calculations are unacceptable.

1.5 REGULATORY AGENCY APPROVALS

A. Submittals for arc-flash hazard analysis require action by Architect prior to submitting for approval by authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

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

1. EasyPower, LLC (formerly ESA Inc.).
2. ETAP - Digital Twin Platform.
3. SKM Systems Analysis, Inc.
4. Or approved equal

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings, including derating factors and environmental conditions.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 73 "Short-Circuit Studies."

F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 26 05 74 "Coordination Studies."

G. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
   g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Restricted approach boundary.
6. Limited approach boundary.
7. Working distance.
8. Incident energy.
9. Hazard risk category.
10. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce 3.5 by 5 inch self-adhesive equipment label for each work location included in analysis.

B. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Protection boundaries.
   a. Arc-flash boundary.
   b. Restricted approach boundary.
   c. Limited approach boundary.
4. Arc flash PPE category.
5. Required minimum arc rating of PPE in Cal/cm squared.
6. Available incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels must be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies: Perform Short-Circuit and Protective Device Coordination studies prior to starting Arc-Flash Hazard Analysis.

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 73 "Short-Circuit Studies."
2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 26 05 74 "Coordination Studies."

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.

D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment fed from transformers smaller than 75 kVA.

F. Calculate limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must take into account changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).

H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:

1. When circuit breaker is in separate enclosure.
2. When line terminals of circuit breaker are separate from work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain data necessary for conduct of arc-flash hazard analysis.

1. Verify completeness of data supplied on one-line diagram on Drawings. Call discrepancies to Architect's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

3.4 LABELING

A. Apply one arc-flash label on front cover of each section of equipment for each equipment included in study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below not fed by single transformer smaller than 75 kVA must have arc-flash label applied to it:

1. Low-voltage switchgear
2. Switchboards.
3. Panelboards.
4. Motor-control centers.
5. Low voltage transformers.
6. Safety switches.
7. Control panels.
8. .

C. Note on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

END OF SECTION 26 05 75

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SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor occupancy and vacancy sensors.
2. Switchbox-mounted occupancy sensors.
3. Outdoor motion sensors.
4. Conductors and cables.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 26 27 26 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings:

1. Show installation details for the following:
   a. Occupancy sensors.
   b. Vacancy sensors.
2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY AND VACANCY SENSORS

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

1. Lutron Lighting; Lutron Electronics Co, Inc
2. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. nLight; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. Philips; Signify North America; Signify Holding.
8. WattStopper; Legrand North America, LLC.

9. Or approved equal.

B. General Requirements for Sensors:

1. Wall/Ceiling-mounted, solid-state indoor occupancy sensors.
2. Dual technology.
3. Integrated or separate power pack.
4. Hardwired connection to switch lighting control system.
5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
6. Operation:
   a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
7. Sensor Output: powered from the power pack.
8. Power: Line voltage.
9. 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.
10. Mounting:
    a. Sensor: Suitable for mounting in any position in a standard device box or 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.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Wall/Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. 2000 sq. ft. [**3000 sq. ft.**] when mounted 48 inch above finished floor.

2.2 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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

1. Lutron Lighting; Lutron Electronics Co, Inc
2. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. nLight; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. Philips; Signify North America; Signify Holding.
8. Square D; Schneider Electric USA.
9. WattStopper; Legrand North America, LLC.
10. Or approved equal.

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 or wireless connection.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800 VA LED load at 120 V, 1200 VA LED load at 277 V, and 800 W incandescent.

C. Wall-Switch Sensor:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, SP, manual "on," automatic "off"
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
9. Color: White.
10. Faceplate: Color matched to switch.

2.3 OUTDOOR MOTION SENSORS

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

1. Lutron Lighting; Lutron Electronics Co, Inc
2. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. nLight; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. WattStopper; Legrand North America, LLC.
8. Or approved equal.

B. Description: Solid-state outdoor motion sensors.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Dual-technology (PIR and ultrasonic) type, weatherproof. Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch. Comply with UL 773A.
3. Switch Rating:
   a. Luminaire-Mounted Sensor: 500 VA LED.
   b. Separately Mounted Sensor: 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.
4. Switch Type: SP, SP, manual "on," automatic "off".
5. Voltage: Match the circuit voltage.
6. Detector Coverage:
   a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft..
   b. Long Range: 180-degree field of view and 110 ft. detection range.
7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
10. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as "raintight" in accordance with UL 773A.

2.4 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-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 Cable: Multiconductor cable with stranded-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 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

3.2 INSTALLATION OF CONTACTORS

A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 26 05 53 "Identification for Electrical Systems.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. 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. Nonconforming Work:

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Manufacturer Services:

1. Engage factory-authorized service representative to [support] [supervise] field tests and inspections.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual

occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

END OF SECTION 26 09 23

SECTION 26 22 13

LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.02 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.
5. Substitution - Or Approved Equal.

2.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

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 qualified electrical testing laboratory recognized by authorities having jurisdiction.

2.03 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.

C. Coils: Continuous windings without splices except for taps.

1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

D. Enclosure: Ventilated.

1. Core and coil must 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.
4. Environmental Protection:
   a. Indoor: UL 50E, Type 2.

E. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity .

F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

G. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 80 deg C rise above 40 deg C ambient temperature.

H. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

I. Wall Brackets: Manufacturer's standard brackets .

2.04 IDENTIFICATION

A. Nameplates:

1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.

E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.

3.02 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer .

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in

B. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

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.

C. Secure transformer to concrete base in accordance with manufacturer's published instructions.

D. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

E. Remove shipping bolts, blocking, and wedges.

3.03 CONNECTIONS

A. Ground equipment in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals in accordance with 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 conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.04 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:
   a. Visual and Mechanical Inspection.
      1) Inspect physical and mechanical condition.
      2) Inspect anchorage, alignment, and grounding.
      3) Verify that resilient mounts are free and that shipping brackets have been removed.
      4) Verify that unit is clean.
      5) Perform specific inspections and mechanical tests recommended by manufacturer.
      6) Verify that as-left tap connections are as specified.
      7) Verify presence of surge arresters and that their ratings are as specified.
   b. Electrical Tests:
      1) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

B. Nonconforming Work:

1. Transformer will be considered defective if it does not pass tests and inspections.
2. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Assemble and submit test and inspection reports.

3.05 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 13

SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Switchboards.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.

B. Related Requirements

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Switchboards.
2. Overcurrent protective devices.
3. Surge protection devices.
4. Groud-fault protection devices.
5. Accessories.
6. Other components.
7. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than UL 50E, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.03 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Handling, storing, and providing temporary heat.
2. Mounting accessories and anchoring devices.
3. Testing and adjusting overcurrent protective devices.

B. Sample warranties.

1.04 CLOSEOUT SUBMITTALS

PART 2 - PRODUCTS

2.01 SWITCHBOARDS

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

1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.
5. Or Approved Equal

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

G. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

H. Nominal System Voltage: 208Y/120 V .

I. Indoor Enclosures: Steel, UL 50E, Type 1 .

J. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over rust-inhibiting primer on treated metal surface.

K. Service Entrance Rating: Switchboards intended for use as service entrance equipment may contain from one to six service disconnecting means with overcurrent protection, neutral bus with disconnecting link, grounding electrode conductor terminal, and main bonding jumper.

L. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchboard.

M. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

N. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Removable covers may form top, front, and sides. Top covers at rear must be easily removable for drilling and cutting.
3. Bottom must be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports must be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

O. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from front of switchboard.
2. Ground Bus: 1/4 by 2 inch hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
3. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
4. Disconnect Links:
   a. Isolate neutral bus from incoming neutral conductors.
   b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
5. Neutral Buses: 100 percent of ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

2.02 SURGE PROTECTION DEVICES

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

1. ABB, Electrification Business.
2. Advanced Protection Technologies Inc. (APT).
3. Eaton.
4. Siemens Industry, Inc., Energy Management Division.
5. Square D; Schneider Electric USA.
6. Or Approved Equal

B. SPDs: Listed and labeled in accordance with UL 1449, Type 1 .

C. Features and Accessories:

1. Internal thermal protection that disconnects SPD before damaging internal suppressor components.
2. Indicator light display for protection status.
3. Form-C contacts rated at 5 A and 250 V(ac) , one normally open and one normally closed, for remote monitoring of protection status.
4. Surge counter.

D. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase may not be less than 200 kA . Peak surge current rating must be arithmetic sum of ratings of individual MOVs in each mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits may not exceed the following:

1. Line to Neutral: 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 208Y/120 V.
3. Line to Line: 1000 V for 208Y/120 V.

F. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits may not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 1000 V.
3. Line to Line: 1000 V.

G. SCCR: Equal or exceed 100 kA .

H. Nominal Rating: 20 kA.

2.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. 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. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Switchboards and Accessories: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 2.1.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Equipment Mounting: Install switchboards on concrete base, 4 inch nominal thickness. Comply with requirements for concrete base specified in Section 26 05 29 "Hangers and Supports for Electrical Systems."
   a. Install conduits entering underneath switchboard, entering under vertical section where conductors will terminate. Install with couplings flush with concrete base. Extend 2 inch above concrete base after switchboard is anchored in place.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of concrete base.

c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, published instructions, and directions furnished with items to be embedded.
e. Install anchor bolts to elevations required for proper attachment to switchboards.
f. Anchor switchboard to building structure at top of switchboard if required or recommended by manufacturer.

2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
3. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."
4. Operating Instructions: Frame and mount printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
5. Install filler plates in unused spaces of panel-mounted sections.
6. Install overcurrent protective devices, surge protection devices, and instrumentation.
   a. Set field-adjustable switches and circuit-breaker trip ranges.

3.02 CONNECTIONS

A. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.

B. Support and secure conductors within switchboard in accordance with NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

D. Service Equipment Label: Labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

END OF SECTION 26 24 13

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SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

A. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. MCCB: Molded-case circuit breaker.

B. SPD: Surge protective device.

1.3 SUBMITTALS

A. Product Data: For each type of panelboard.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Configuration diagram of panel and breakers.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.6 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 COMMON 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. Comply with NEMA PB 1.

C. Comply with NFPA 70.

D. Enclosures: Flush and Surface-mounted, 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 .
2. Height: 84 inches maximum.
3. 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.

E. Incoming Mains Location: Convertible between top and bottom.

F. Phase, Neutral, and Ground Buses: Tin-plated aluminum .

G. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated aluminum .
2. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

H. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

J. 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.

2.2 PERFORMANCE REQUIREMENTS

2.3 POWER PANELBOARDS

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

1. ABB, Electrification Business.
2. Eaton.
3. Mersen USA.
4. Siemens Industry, Inc., Energy Management Division.
5. Square D; Schneider Electric USA.
6. Or approved equal.

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: Circuit breaker or Lugs only, as indicated on drawings.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers .

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, undefined:

1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.
5. Or approved equal.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only, as indicated on drawings.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, undefined:

1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.
5. –Or approved equal.

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 200 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:
   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.
4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
5. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   e. Ground-Fault Protection: relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.6 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: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

2.7 ACCESSORY COMPONENTS AND FEATURES

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NEMA PB 1.1.

C. Mount top of trim 90 inches above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box.

E. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

F. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

G. 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.

H. Install filler plates in unused spaces.

I. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 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.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection for low-voltage air circuit breakers
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

END OF SECTION 26 24 16

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SECTION 26 27 02

EQUIPMENT WIRING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Misc. Equipment
2. HVAC and Plumbing motors, VFDs, and panels
3. Elevators

B. RELATED WORK

1. Applicable provisions of Division 1 govern work under this Section.
2. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
3. Section 26 05 33 – Raceway and Boxes for Electrical Systems
4. Section 26 27 29 - Elevator Distribution Equipment
5. Section 01 91 00 – Commissioning Process

C. SUBMITTALS

1. Product Data: Provide data for cord and wiring devices.

D. COORDINATION

1. Coordinate all equipment requirements with the various contractors and the Owner. Review the complete set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required.
2. Coordinate the available fault current at equipment including control panels and internal components. Equipment shall be listed to interrupt the available fault current at point of connection.

PART 2 - PRODUCTS

2.01 CORDS AND CAPS

A. Straight-blade Attachment Plug: NEMA WD 1.

B. Locking-blade Attachment Plug: NEMA WD 5.

C. Attachment Plug Configuration: Match receptacle configuration at outlet provided for equipment.

D. Cord Construction: Oil-resistant thermoset insulated multi-conductor flexible cord with identified equipment grounding conductor, suitable for hard usage in damp locations.

E. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

2.02 OTHER PRODUCTS

A. Refer to related sections for other product requirements.

PART 3 - EXECUTION

3.01 INSPECTION

A. Verify that equipment is ready for electrical connection, wiring, and energizing.

B. Working space for equipment shall be provided that is likely to require examination, adjustment, servicing or maintenance per NEC 110.26(A)(1) table.

3.02 PREPARATION

A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

3.03 INSTALLATION

A. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.

B. Provide a green equipment ground conductor for all installed equipment wiring.

C. Make conduit connections to equipment using flexible PVC-coated metal conduit.

D. Requirements of NEC Article 300.22 shall apply for boxes, conduit, conduit connections to equipment, devices and luminaire located in Mechanical Plenum spaces.

E. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.

F. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.

G. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.

H. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.

I. All 120V single phase motor operated equipment such as fan coil units, unit heaters, door operators, shall be provided with a SSY, 2 gang combination plug fuse holder/ switch mounted adjacent to equipment.

3.04 MISCELLANEOUS CONNECTIONS

A. Hand Dryers: Provide handle lock on source circuit breaker to serve as required lock open disconnect.

B. Drinking Fountains and Bottle Fill Fountains: Provide GFCI source circuit breaker to serve receptacle at fountain.

C. Knox Box: Provide 3/4” conduit stubbed between Knox Box and nearest interior location above accessible ceiling.

3.05 HVAC AND PLUMBING CONNECTIONS

A. Provide all power wiring including all circuitry carrying electrical energy from panelboard or other source through starters, variable frequency drives (VFDs), controller overcurrent protection and disconnects to motors or to packaged control motor protection panels.

B. Packaged control motor protection panels may include disconnects and starters and overcurrent protection. Provide all wiring between source and packaged control motor protection panel and motors. Install panel on exterior wall or adjacent to AHU’s.

C. Contractor shall verify with mechanical contractor the electrical requirements including voltages, horsepower, disconnecting means, starters and variable frequency drives for motors and equipment prior to ordering circuit breakers, disconnects, controller overcurrent protection devices and starters.

D. VFD Installations: 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.

E. VFD Installations: Output power wiring for more than one motor shall not share a common conduit.

F. VFD installations: Provide aux contact in local disconnect to de energize VFD when opening local disconnect.

G. Provide 120 volts to each temperature control panel. Coordinate quantity and exact locations with HVAC/DDC contractors.

H. Unless otherwise specified, all electrical control devices such as aqua-stats, float and pressure switches, fan powered VAV boxes, switches, electro-pneumatic switches, solenoid valves and damper motors requiring mechanical connections shall be furnished and installed and wired by the Contractor supplying the devices.

I. Provide 120V, single phase 20 ampere combination lighting and convenience outlet circuit and switching means to serve field installed receptacles and interior lighting within each HVAC unit. Each access section shall contain a minimum of one marine grade light fixture/ luminaire. Sections wider than 6 feet shall have multiple marine grade light fixtures/luminaire with maximum spacing of 6 feet. Provide separate junction box at exterior of air handling unit.

J. All conduit penetrations to AHU’s shall be sealed by electrical contractor. See Casing Penetrations in 23 73 13, 23 73 23 and 23 73 24 for exact requirements.

K. Each motor terminal box shall be connected with a minimum 12", maximum 36" piece of flexible PVC-coated metal conduit to a fixed junction box. When connections are located in Mechanical Plenum spaces located within Mechanical equipment, flexible metal conduit shall be utilized. Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.

L. Provide separate junction box for each engineered supply, return/relief/exhaust system at exterior of air handling unit for [208V][480V], 3-phase source.

M. All wiring shall be routed in conduit and a minimum of 12 AWG wire shall be used for all luminaires, switches and convenience outlets. All lighting, switches and convenience outlet circuits shall be a minimum of 20 amperes.

N. Provide local disconnect within each walk-in HVAC units to serve as line-of-site local motor disconnect. Disconnect enclosure shall be NEMA 4X stainless steel.

O. Check for proper rotation of each motor.

P. All heating, air conditioning and refrigeration equipment installed on the exterior of the building or rooftop shall have a 120V, single phase, 20 ampere rated outlet at an accessible location within 25 feet of the equipment.

3.06 ELEVATOR CONNECTIONS

A. Disconnect Switch (Power Module) - Fused Elevator Shunt Trip

B. Description: Provide shunt-trip fused disconnect switch with necessary relay(s), control transformer and other options, as required per specification Section 26 27 29.

C. Connections

1. Provide all power wiring from source to elevator controller including disconnect, line accessories equipment such as transformers and line reactors/inductors. Provide final connection between elevator controller and elevator motor. Coordinate with elevator contractor.
2. Provide all ground connections and wiring from building ground bus to elevator controller associated , elevator transformers. Sized per NEC 250.
3. Provide single means of disconnect; manual starter, enclosed circuit breaker or disconnect, labeled "elevator cab lights" located in equipment room Per NEC 620.22. The means of disconnect shall be capable of being locked in the open position. Extend 120 volt circuit from source through lockable switch to controller. Provide one lockable switch and 120 volt circuit per unit. The overcurrent device protecting the branch circuit shall be located in the elevator machine room.
4. Provide 120V, 20 ampere separate branch circuit to serve machine room lighting and receptacle(s) per NEC 620.23. Provide light switch and duplex receptacle(s). A GFCI receptacle shall be located adjacent to elevator motor. The lighting shall not be connected to load side of GFCI.
5. Provide 120V, 20 ampere separate branch circuit to serve elevator pit lighting and receptacle(s) per NEC 620.24. The lighting shall not be connected to load side of GFCI. Electrical installation in elevator pit shall be suitable for wet locations when the pit contains a fire protection sprinkler.
6. Provide 120V, 20 ampere separate branch circuit to serve elevator pit sump pump. Dedicated circuit shall not be GFCI protected. Cord and plug connection, shall be single receptacle. Electrical installation in elevator pit shall be suitable for wet locations when the pit contains a fire protection sprinkler.
7. Provide 120V, 20 ampere separate branch circuits for additional circuits supplying utilization equipment not identified in NEC 620.22, 620.23 and 620.4 but limited to loads per 620.1. Coordinate with elevator manufacturer's requirements. Overcurrent devices protecting these additional loads shall be located in the elevator equipment room.
8. Provide 120V, 20 ampere separate branch circuit to serve hoist way receptacles. Locate receptacles on every other floor above lowest level.

D. Lighting

1. Provide minimum of two (2) luminaires in the elevator pit. Electrical installation in elevator pit shall be suitable for wet locations when the pit contains a fire protection sprinkler.
2. Provide switch adjacent to pit access ladder, 36" above door sill.
3. Provide luminaires as required to maintain a minimum of 10 FC throughout the elevator pit.
4. Provide luminaires as required to maintain a minimum of 19 FC throughout the elevator equipment room or required working clearance around equipment in room-less equipment locations (equipment integral with elevator car).
5. Provide elevator lobby lighting to provide minimum 10 FC at elevator door (s) with the door (s) closed.

E. Lighting - Hoistways

1. Provide lighting on every [other] floor above lowest level [as required to maintain a minimum of 1 FC throughout the hoistway]. Provide 3-way and 4-way switches.

F. Miscellaneous connections

1. Provide all wiring for and mount exterior alarm bell. Feed from emergency source.
2. Provide smoke detector in each elevator equipment room or space. Connect main alarm contacts to fire alarm system and auxiliary contacts to the controller.
3. Provide smoke detector in each elevator lobby. Connect main alarm contacts to fire alarm system and auxiliary contacts to elevator controller.
4. All traveling cables, control stations, control station wiring and final control connections at the controller shall be furnished and installed under Division 14 Elevator Work.
5. All elevator wiring from elevator controller shall be installed with raceway connectors. Hoistway cabling shall utilize raceway connectors or bushings at entrance to equipment enclosure.
6. Provide 3/4" conduit from controller to nearest telephone wiring closet (IDF) with four pair UTP Cat.-5e or better cable.
7. Coordinate entire installation with Division 14 Contractor prior to rough-in.
8. Coordinate entire installation with Division 27 contractor prior to rough-in for communication and security requirements.

3.07 EQUIPMENT CONNECTION SCHEDULE

A. As indicated on the drawings.

END OF SECTION 26 27 02

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SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Receptacles with ground-fault protective devices.

B. Related Requirements:

1. 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section. for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 01 31 00 "Project Management and Coordination" for preinstallation conference procedures.
3. Section 26 09 23 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.

1.2 SUBMITTALS

A. Product Data:

1. Toggle switches.
2. Single straight-blade receptacles
3. Duplex straight-blade receptacles.
4. Receptacles with GFCI device.

B. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

1.3 WARRANTY FOR DEVICES

A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.

1. Initial Warranty Period: 1 year from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

A. Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
   e. Or approved equal.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN WMUZ and UL 20.
4. Options:
   a. Device Color: Office White.
   b. Configuration:
      1) General-duty, 120-277 V, 20 A, single pole.
5. Accessories:
   a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.2 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

A. Single Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
   e. Or approved equal.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
   a. Device Color: Office White.
   b. Configuration:
      1) General-duty, NEMA 5-20R.
5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
   e. Or approved equal.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
   a. Device Color: Office White.
   b. Configuration:
      1) General-duty, NEMA 5-20R.
5. Accessories:
   a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Tamper-Resistant Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
   e. Or approved equal.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
   a. Device Color: Office White.
   b. Configuration:
      1) General-duty, NEMA 5-20R.
5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

C. Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
   e. Or approved equal.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
   a. Device Color: Office White.
   b. Configuration:
      1) General-duty, NEMA 5-20R; two USB-A ports.
5. Accessories:
   a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 RECEPTACLES WITH GROUND-FAULT PROTECTIVE DEVICES

A. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
   e. Or approved equal.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
4. Options:
   a. Device Color: Office White.
   b. Configuration: Heavy-duty, NEMA 5-20R.
5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION OF SWITCHES

A. Comply with manufacturer's instructions.

B. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 26 05 53 "Identification for Electrical Systems."

3.3 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 26 05 53 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL OF SWITCHES

A. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' instructions.

B. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

3.5 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

3.6 PROTECTION

A. Devices:

1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26

SECTION 26 32 13.13

DIESEL-ENGINE-DRIVEN GENERATOR SETS

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. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Load bank.

B. Related Requirements:

1. Section 26 36 00 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.3 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators 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. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
   b. Operating instructions laminated and mounted adjacent to generator location.
   c. Training plan.

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. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of registered commissioning and start-up.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Blue Star Power Systems.

2. Caterpillar, Inc.; Electric Power Division.
3. Cummins Power Generation.
4. Generac.
5. Kohler Power Systems.
6. Or Approved Equal.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. B11 Compliance: Comply with B11.19.

B. NFPA Compliance:

1. Comply with NFPA 37.(Standard For the Installation and Use of Stationary Combustion Engines and Gas Turbines)
2. Comply with NFPA 70. (National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702)
3. Comply with NFPA 99 (Essential Electrical Systems for Health Care Facilities) .
4. Comply with NFPA 110 requirements for Level 1 EPSS.

C. UL Compliance: Comply with UL 2200.

D. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

E. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 104 deg F.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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 use.

C. Power Rating: Standby.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. EPSS Class: Engine generator shall be classified as a Class 2 according to NFPA 110.

F. Service Load: Refer to drawings and schedule.

G. Power Factor: 0.8, lagging.

H. Frequency: 60 Hz.

I. Voltage: Refer to drawings and schedule.

J. Phase: Three-phase, four wire, wye.

K. Induction Method: Turbocharged.

L. Governor: Adjustable isochronous, with speed sensing.

M. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

N. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

O. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time:
   a. Comply with NFPA 110, Type 10 system requirements.
   b. 10 seconds.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499 and with NFPA 110 requirements for Level 1 equipment for heater capacity.

E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
   a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer:

1. Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   a. Minimum sound attenuation of 12 dB at 500 Hz.
   b. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 90 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for nickel cadmium batteries. Unit shall comply with UL 1236 and include the following features:
    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 37.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 23 11 13 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Fuel-Oil Storage Tank: Comply with requirements in Section 23 13 23 Facility Aboveground Fuel-Oil Storage Tanks.

1. Fuel Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 8 hours' operation at 100 percent of rated power output of engine generator system without being refilled.

G. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for planned operation plus fuel for periodic maintenance operations between fuel refills.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration:

1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

E. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
   a. Engine lubricating-oil pressure gage.
   b. Engine-coolant temperature gage.
   c. DC voltmeter (alternator battery charging).
   d. Running-time meter.
   e. AC voltmeter, for each phase.
   f. AC ammeter, for each phase.
   g. AC frequency meter.
   h. Generator-voltage adjusting rheostat.
2. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:
   a. Cranking control equipment.
   b. Run-Off-Auto switch.
   c. Control switch not in automatic position alarm.
   d. Overcrank alarm.

e. Overcrank shutdown device.
f. Low-water temperature alarm.
g. High engine temperature prealarm.
h. High engine temperature.
i. High engine temperature shutdown device.
j. Overspeed alarm.
k. Overspeed shutdown device.
l. Low fuel main tank.
    1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required for the indicated EPSS class.
m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature prealarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS load indicator.
t. Battery high-voltage alarm.
u. Low cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Generator overcurrent-protective-device not-closed alarm.
ff. Hours of operation.
gg. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

F. Engine Generator Metering: Comply with Section 26 27 13 "Electricity Metering."

G. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via ModBus. Data system connections to terminals are covered in Section 26 09 13 "Electrical Power Monitoring and Control."

H. Control Wire Monitoring System: Comply with NEC 700.10 (D) for control module for continuous monitoring of control wires between automatic transfer switches and generator. Generator control module to be able to monitor up to six (6) automatic transfer switches,

I. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

J. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until

silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent-protective-device not-closed alarm.

K. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:

1. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
   a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
   b. Trip Settings: Selected to coordinate with generator thermal damage curve.
   c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
   d. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six-lead alternator.

E. Range: Provide limited range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 15 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 5 percent and stabilize at rated frequency within 5 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 LOAD BANK

A. Description:

1. Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, unit capable of providing a balanced three-phase, delta-connected load to engine generator at percent rated-system capacity, at percent power factor, lagging. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
2. Permanent, radiator-mounted unit capable of providing a balanced three-phase, delta-connected load to engine generator at percent rated-system capacity. Unit shall be capable of selective control of load in 25 percent steps of load-bank rating and with minimum step changes of approximately 5 and 10 percent available.

B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.

C. Reactive Load Elements: Epoxy-encapsulated reactor coils.

D. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.

E. Load-Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.

F. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.

G. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge. Components other than resistive elements shall receive exterior epoxy coating with compatible primer. Comply with requirements in Section 09 96 00 "High-Performance Coatings."

H. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.

I. Load-Bank Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.

J. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

2.10 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer. Color selected by owner from Manufacturer's standard colors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

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

3.2 PREPARATION

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and heat exchanger. Piping materials and installation requirements are specified in Section 23 21 13 "Hydronic Piping."

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches of clearance from combustibles.
2. Insulate cooling-system piping and components according to requirements in Section 23 07 19 "HVAC Piping Insulation."

F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 23 21 13 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 23 21 16 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 23 07 19 "HVAC Piping Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches of clearance from combustibles.

G. Drain Piping: Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 23 21 13 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 23 21 16 "Hydronic Piping Specialties."

H. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 23 11 13 "Facility Fuel-Oil Piping."
2. Copper and galvanized steel shall not be used in the fuel-oil piping system.

I. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

J. Control Wiring: All generator control conductors installed between transfer equipment and the emergency generator serving Emergency, Legally Required Standby and Optional Standby systems shall be kept entirely independent of each other and all other wiring. This shall require a dedicated conduit system between each transfer switch and the emergency generator.

3.4 CONNECTIONS

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

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect fuel piping to engines with a gate valve and union and flexible connector.

D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

F. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 23 05 53 "Identification for HVAC Piping and Equipment" and Section 26 05 53 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency:

1. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.
    a. Visual and Mechanical Inspection:
        1) Compare equipment nameplate data with Drawings and the Specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify that the unit is clean.
    b. Electrical and Mechanical Tests:
        1) Perform insulation-resistance tests according to IEEE 43.
            a) Machines Larger Than 200 hp: Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Perform vibration test for each main bearing cap.
        6) Verify correct functioning of the governor and regulator.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.
4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet from edge of the generator enclosure, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

3.7 DEMONSTRATION

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

END OF SECTION 26 32 13.13

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SECTION 26 36 00

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 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.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 110.

D. Comply with UL 1008 unless requirements of these Specifications are stricter.

E. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Short-time withstand capability for 6 cycles.

F. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

G. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

H. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be

mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

I. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 26 05 53 "Identification for Electrical Systems."

1. Designated Terminals: Mechanical type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via rear access.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

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

1. ASCO Power Technologies.
2. Cummins Power Generation.
3. Eaton.
4. Generac.
5. Kohler Power Systems.
6. Or Approved Equal.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Tin-plated aluminum .
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. .Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of

nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

3. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
4. Test Switch: Simulate normal-source failure.
5. Switch-Position Pilot Lights: Indicate source to which load is connected.
6. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
   b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
7. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
8. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
9. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
10. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
11. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.
12. Control Wire Monitoring: Each transfer switch to have continuous engine start circuit monitoring. Loss of integrity of the remote start circuit(s) shall initiate visual and audible annunciation of generator malfunction at the generator local and remote annunciator(s) and start the generator(s).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

B. Identify components according to Section 26 05 53 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. 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 within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

E. Connect twisted pair cable according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

F. Route and brace conductors according to manufacturer's written instructions and Section 26 05 29 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

G. Brace and support equipment according to Section 26 05 48.16 "Seismic Controls for Electrical Systems."

H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

I. Control Wiring: All generator control conductors installed between transfer equipment and the emergency generator serving Emergency, Legally Required Standby and Optional Standby systems shall be kept entirely independent of each other and all other wiring. This shall require a dedicated conduit system between each transfer switch and the emergency generator.

J. All Emergency branch control conductors installed between transfer equipment and the emergency generator shall be installed per NEC 700.10(D)(1) through (D)(3).

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify that the unit is clean.
   e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   f. Verify that manual transfer warnings are attached and visible.
   g. Verify tightness of all control connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
   i. Perform manual transfer operation.
   j. Verify positive mechanical interlocking between normal and alternate sources.
   k. Perform visual and mechanical inspection of surge arresters.
   l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

2. Electrical Tests:
   a. Perform insulation-resistance tests on all control wiring with respect to ground.

B. Coordinate tests with tests of generator and run them concurrently.

C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

D. Transfer switches will be considered defective if they do not pass tests and inspections.

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

F. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00

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SECTION 26 43 13

SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Type 1 surge protective devices.
2. Enclosures.

B. Related Requirements:

1. Section 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section. for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 26 24 13 "Switchboards" for integral SPDs installed by switchboard manufacturer.
3. Section 26 24 16 "Panelboards" for integral SPDs installed by panelboard manufacturer.

1.2 DEFINITIONS

A. In: Nominal discharge current.

B. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 SUBMITTALS

A. Product Data:

1. For each type of product.
    a. Include electrical characteristics, specialties, and accessories for SPDs.
    b. Certification of compliance with UL 1449 by qualified electrical testing laboratory recognized by authorities having jurisdiction including the following information:
        1) Tested values for VPRs.
        2) In ratings.
        3) MCOV, type designations.
        4) OCPD requirements.
        5) Manufacturer's model number.
        6) System voltage.
        7) Modes of protection.

1.4 INFORMATIONAL SUBMITTALS

1.5 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Five year(s) from date of Substantial Completion, for labor, materials, and equipment.
2. Follow-On Extended Warranty Period: 10 year(s) from date of Substantial Completion, for materials only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

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

1. ABB, Electrification Business.
2. Eaton.
3. Intermatic, Inc.
4. Schneider Electric USA, Inc.
5. Siemens Industry, Inc., Energy Management Division.
6. SSI, an ILSCO Company.
7. Or approved equal

B. Source Limitations: Obtain devices from single source from single manufacturer.

C. General Characteristics:

1. Reference Standards: UL 1449, Type 1.
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 200 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V 208Y/120 V, three-phase, four-wire circuits must not exceed the following:
   a. Line to Neutral: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
   b. Line to Line: 2000 V for 480Y/277 V 1200 V for 208Y/120 V.
5. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:
   a. Line to Neutral: 700 V.
   b. Line to Line: 1200 V.
6. SCCR: Not less than 100 kA.
7. In Rating: 20 kA.

D. Options:

1. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
2. Include indicator light display for protection status.
3. Include audible alarm.
4. Include surge counter.

2.2 ENCLOSURES

A. Indoor Enclosures: Type 1.

B. Outdoor Enclosures: Type 3R .

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.

3.2 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 26 43 13

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SECTION 26 51 19

LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of LED luminaires:

1. Linear industrial.
2. Parking garage.
3. Recessed, linear.
4. Strip light.
5. Surface mount, linear.
6. Surface mount, nonlinear.

B. Related Requirements:

1. Section 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section. for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2

A. Product Data: For each type of product.

1. 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.
2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 SUBMITTALS

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Provide luminaires from a single manufacturer for each luminaire type.

B. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.6 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. 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.

1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

D. Electrical Requirements: Refer to electrical plans and light fixture schedule for voltage requirements.

2.3 LINEAR INDUSTRIAL.

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

1. Axlen LED Lighting.
2. Cooper Lighting Solutions; Signify North America Corp.
3. GE Current, a Daintree company; American Industrial Partner
4. s (AIP).
5. Hubbell Lighting.
6. Lighting Science Group.
7. Lithonia Lighting; Acuity Brands Lighting, Inc.
8. OSRAM SYLVANIA.
9. RAB Lighting.
10. Or approved equal

B. Lamp:

1. Minimum allowable efficacy of 80 lm/W.
2. CRI of minimum 80 . CCT as indicated on schedule .

3. Rated lamp life of 50,000 hours to L70.
4. Dimmable from 100 percent to one (1) percent of maximum light output.
5. Internal driver.
6. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Color as indicated on light fixture schedule and selected from manufacturer's standard colors.

D. Housing and Heat Sink Rating:

1. NEMA 250, Type 4X.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. Prismatic acrylic .
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

G. With integral mounting provisions.

H. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.

2.4 PARKING GARAGE

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

2.5 STRIP LIGHT.

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

1. Cooper Lighting Solutions; Signify North America Corp.
2. GE Current, a Daintree company; American Industrial Partners (AIP).
3. Hubbell Lighting.
4. Lighting Science Group.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. OSRAM SYLVANIA.
7. Signify North America Corporation (formerly Philips Lighting).
8. Or approved equal

B. Lamp:

1. Minimum 750 lm.

2. Minimum allowable efficacy of 75 lm/W.
3. CRI of minimum 80 . CCT as indicated on schedule .
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to one (1) percent of maximum light output.
6. Internal driver.
7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Color as indicated on light fixture schedule and selected from manufacturer's standard colors.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping of luminaire without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. Prismatic acrylic .
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.6 SURFACE MOUNT, LINEAR.

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

1. Architectural Lighting Works.
2. Axis Lighting, Inc.
3. Cooper Lighting Solutions; Signify North America Corp.
4. Finelite.
5. GE Current, a Daintree company; American Industrial Partners (AIP).
6. Hubbell Lighting.
7. Lighting Science Group.
8. Lithonia Lighting; Acuity Brands Lighting, Inc.
9. Lumen Pulse.
10. OSRAM SYLVANIA.
11. Signify North America Corporation (formerly Philips Lighting).
12. Tech Lighting.
13. Or approved equal

B. Lamp:

1. Minimum 750 lm.
2. Minimum allowable efficacy of 75 lm/W.

3. CRI of minimum 80 . CCT as indicated on schedule .
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to one (1) zero percent of maximum light output.
6. Internal driver.
7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Color as indicated on light fixture schedule and selected from manufacturer's standard colors.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. Prismatic acrylic .
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.7 SURFACE MOUNT, NONLINEAR

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

1. Architectural Lighting Works.
2. Cooper Lighting Solutions; Signify North America Corp.
3. GE Current, a Daintree company; American Industrial Partners (AIP).
4. Hubbell Lighting.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lumen Pulse.
7. OSRAM SYLVANIA.
8. Signify North America Corporation (formerly Philips Lighting).
9. Tech Lighting.
10. Or approved equal

B. Lamp:

1. Minimum 750 lm.
2. Minimum allowable efficacy of 75 lm/W.
3. CRI of minimum 80 . CCT as indicated on schedule .
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to one (1) percent of maximum light output.
6. Internal driver.

7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Color as indicated on light fixture schedule and selected from manufacturer's standard colors.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. Prismatic acrylic .
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.8 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. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.9 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.

2.10 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 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. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

END OF SECTION 26 51 19

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SECTION 26 52 13

EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Emergency lighting.
2. Exit signs.
3. Materials.
4. Luminaire support components.

B. Related Requirements:

1. Section 26 00 10 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.02 ACTION SUBMITTALS

A. Product Data:

1. For each type of emergency lighting unit, exit sign, and emergency lighting support.
   a. Include data on features, accessories, and finishes.
   b. Include physical description of unit and dimensions.
   c. Battery and charger for light units.
   d. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
   e. Include photometric data and adjustment factors based on laboratory tests by, or under supervision of, qualified luminaire photometric testing laboratory, for each luminaire type.

B. Shop Drawings:

1. For nonstandard or custom luminaires.
   a. Include plans, elevations, sections, and mounting and attachment details.
   b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   c. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

1.04 WARRANTY

A. Special Manufacturer Extended Warranty for Batteries for Emergency and Exit Lighting: Manufacturer warrants that batteries for emergency luminaires and exit signs perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended warranty period.

1. Extended Warranty Period: Five year(s) from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 and UL 924, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with NFPA 101.

C. Comply with NEMA LE 4 for recessed luminaires.

D. Comply with UL 1598 for fluorescent luminaires.

E. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.

1. Emergency Connection: Operate one lamp(s) continuously at an output of at least 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.02 EMERGENCY LIGHTING

A. General Characteristics: Self-contained units.

B. Emergency Luminaire:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper Lighting Solutions; Signify North America Corp.
   b. Dual-Lite; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Lithonia Lighting; Acuity Brands Lighting, Inc.
   d. Signify North America Corporation (formerly Philips Lighting).
   e. Substitution - Or Approved Equal.
2. Options:

a. Nominal Voltage: Refer to electrical drawings and light fixture schedule. .
b. Internal emergency power unit.
c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.
d. UL 94 5VA flame rating.

C. Emergency Lighting Unit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper Lighting Solutions; Signify North America Corp.
   b. Dual-Lite; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Lithonia Lighting; Acuity Brands Lighting, Inc.
   d. Substitution - Or Approved Equal.
2. Options:
   a. Nominal Voltage: Refer to electrical drawings and light fixture schedule. .
   b. Wall with universal junction box adaptor.
   c. UV stable thermoplastic housing.
   d. Two LED lamp heads.
   e. Internal emergency power unit.

2.03 EXIT SIGNS

A. General Characteristics: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Sign:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper Lighting Solutions; Signify North America Corp.
   b. Lithonia Lighting; Acuity Brands Lighting, Inc.
   c. Signify North America Corporation (formerly Philips Lighting).
   d. Substitution - Or Approved Equal.
2. Options:
   a. Nominal Voltage: Refer to electrical drawings and light fixture schedule. .
   b. Lamps for AC Operation:
      1) LEDs; 50,000 hours minimum rated lamp life.
   c. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

2.04 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components must 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.

C. Diffusers and Globes:

1. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing.
2. White powder coat finish.

E. Conduit: EMT, minimum metric designator 21 (trade size 3/4).

2.05 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 range of approved Samples and are assembled or installed to minimize contrast.

2.06 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

3.01 INSTALLATION

A. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

3.02 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.03 FIELD QUALITY CONTROL

A. 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. Nonconforming Work:

1. Luminaire will be considered defective if it does not pass operation tests and inspections.
2. Remove and replace defective units and retest.

C. Prepare test and inspection reports.

3.04 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect luminaires. Replace lamps, emergency power units , batteries, exit signs, and luminaires that are defective.
    a. Parts and supplies must be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.

3.05 PROTECTION

A. Remove and replace luminaires and exit signs that are damaged or caused to be unfit for use by construction activities.

END OF SECTION 26 52 13

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SECTION 26 56 19

LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 26 05 00 "Common Work Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section. for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.

2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.5 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.6 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: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. Lamp base complying with ANSI C81.61 .

E. CRI of 80 . CCT of 3000 K .

F. L70 lamp life of 50,000 hours.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Nominal Operating Voltage: Refer to light fixture schedule.

I. In-line Fusing: On the primary for each luminaire .

J. Lamp Rating: Lamp marked for outdoor use .

K. Source Limitations:

1. For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

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

a. Architectural Area Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Atlas Lighting Products.
c. Cooper Lighting Solutions; Signify North America Corp.
d. GE Current, a Daintree company; American Industrial Partners (AIP).
e. Juno Lighting Group by Schneider Electric.
f. Kim Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. Lithonia Lighting; Acuity Brands Lighting, Inc.
h. Signify North America Corporation (formerly Philips Lighting).
i. Or approved equal

2. Product Performance: Refer to light fixture schedule for performance requirements, finish, voltage, and mounting height,

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum . Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. 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.

B. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color:
      1) As selected from manufacturer's standard catalog of colors.

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 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Fasten luminaire to structural support.

C. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
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.

D. Wall-Mounted Luminaire Support:

1. Attached using through bolts and backing plates on either side of wall .

E. Wiring Method: Install cables in raceways. Conceal raceways and cables.

F. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

G. Coordinate layout and installation of luminaires with other construction.

H. Adjust luminaires that require field adjustment or aiming.

I. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 05 33 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.2 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.3 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. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

C. Coordinate "Operational Test" Subparagraph below with requirements in Section 26 09 23 "Lighting Control Devices."

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

D. Illumination Tests:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

E. Luminaire will be considered defective if it does not pass tests and inspections.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION 26 56 19

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SECTION 27 00 05

STRUCTURED COMMUNICATIONS CABLING

PART 1 GENERAL

1.1 SCOPE OF WORK

A. This document specifies THE CITY OF MADISON requirements for product design, performance, and quality assurance, and contractor responsibilities for execution of work to install a complete Category 6 structured cabling system. Execution of work includes delivery and storage of materials, preparation, installation, field-testing, and project completion tasks. System certification and warranty submittal requirements for completed work and future moves, additions and changes (MAC's) are also specified in this document. Compliance to applicable codes, standards and regulations is required for all construction work performed.

1.2 SUMMARY

A. Section includes products and execution requirements pertaining to Division 27 systems. Copper and fiber backbone and horizontal cabling along with support systems are covered under this document.

B. Product specifications, general design considerations, and installation guidelines are provided in this document. Quantities for all cabling products shall be provided as required to complete cabling to all work stations as shown on floor plans.

C. The Approved Contractor shall furnish, supply and install a complete Category 6 cabling infrastructure specified in the contract documents.

D. Construction work shall comply with contract drawings, specifications, project completion schedules, and applicable codes and standards.

E. Work shall include all detailed execution requirements, such as preparation, installation, system certification, and project closeout activities according to the contract.

F. Substitutions: No substituted products shall be installed except with written approval by Owner.

1.3 DATA AND VOICE COMMUNICATIONS CONTRACT WORK

A. General:

1. Furnish all labor, materials, tools, equipment and services for the installation in accordance with general provisions of specifications and the Contract Drawings.
2. Report percentage of work completed on a monthly basis.
3. Completely coordinate with work of all other trades.
4. Provide all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation, whether or not specifically indicated in the Contract Documents.
5. Provide labor for testing horizontal and backbone cabling.
6. Provide Firestopping.
7. Provide Telecommunications grounding and bonding.

B. Provide complete installation for Structured Telecommunications Cabling System including but not limited to:

1. Category 6A UTP horizontal cables.
2. Singlemode optical fiber backbone cables.
3. Work area telecommunication outlets.
4. Wall mounted voice outlets.
5. Equipment mounting racks and rack enclosures.
6. Category 6A modular patch panels.
7. Optical fiber patch panels.
8. Optical fiber LC connectors.
9. Wire management panels.
10. Field testing.
11. Firestopping.

1.4 SUBMITTALS

A. Submittals shall be complete and at one time. Partial submittals will not be considered.

B. Material lists, schedule of values, lists of subcontractors, and proof of Contractor qualifications shall be provided to Engineer upon request and shall follow the guidelines as stated in the General Requirements (Division 1 of the specification).

C. Show drawings shall be submitted. All communication system shop drawings shall include:

1. Manufacturer's data (specifications, "cut sheets").
2. Wiring diagrams for all installed cabling.
3. Equipment rack/cabinet layouts.
4. Proposed labeling schemes and labeling method.
5. List of cabling distances (typical and maximum) for all structured cabling
6. Submit copies of certifications for all technicians and the project manager who will support this project. The certifications shall include:
7. Structured Cabling and termination equipment installation certifications for copper and optical fiber connectivity and cabling.
8. Approved manufacturer classes satisfactorily completed.
9. Contractor shall submit a test plan that defines the tests required to ensure that the system meets technical, operational, and performance specifications 45 days prior to proposed test date.
10. Work shall not proceed without the Owner's approval of the submitted items.

D. Drawings & Inspection of Site:

1. Communications floor plan drawings are to scale and typically are not dimensioned. The Contractor shall not scale drawings for equipment placement and clearances. Dimensions given on drawings shall always take precedence over scaled drawings.
2. Any existing wires, utilities, or equipment shown on the drawings are shown for general information and to the best knowledge of the Engineer. The Contractor shall field verify all existing wires, utilities, or equipment.

3. The Contractor shall field verify distances and equipment placements coordinating locations with other trades, construction managers, and general Contractor prior to installation.

4. The Contractor shall review all site conditions prior to submitting a bid on this project. Any obvious discrepancies between the site conditions and bidding documents shall be brought to the attention of the Engineer at the time of bidding so clarification can be made by addendum.

5. Change order requests for additional costs related to the contractors misunderstanding related to the amount of work involved and lack of knowledge related to the site conditions will not be allowed.

E. Test Reports: Submit copies of complete reports of all testing performed to the General Contractor, with copies to the Architect's Electrical Engineer upon completion of job.

1.5 APPROVED CONTRACTOR QUALIFICATIONS

A. The Contractor shall have experience in the installation and testing of similar systems as specified herein and shall have completed at least two projects of similar size and scope within the last 24 months. The Contractor shall provide references upon request (including the project name, address, date of implementation, client name, title, telephone number, and project description."

B. All members of the installation team must be certified by the manufacturer as having completed the necessary training to complete their part of the installation. All personnel shall be adequately trained in the used of such tools and equipment as required.

C. The Contractor bidding on communication systems specified herein shall be certified by the connectivity Manufacturer to install, service, and warranty the specified product prior to the time of bid and throughout the duration of the installation. Manufacturer certifications shall not be project specific and should be valid for any and all projects completed by Contractor.

D. The Contractor shall own and maintain tools, installation equipment, and test equipment necessary for successful installation and testing of optical and Category 6 & 6A premise distribution systems.

E. The Owner reserves the right to require the Contractor to remove from the project any such employee the Owner deems to be incompetent, careless or insubordinate.

F. The Contractor must maintain a state Contractor's license as required by the state.

1.6 APPROVED PRODUCT MANUFACTURERS

A. The manufacturer of the Connectivity products specified in this document, as required for construction of the cabling Infrastructure per contract documents shall be:

B. Hubbell Premise Wiring

C. The manufacturer of the Cabling products specified in this document, as required for construction of the copper cable Infrastructure per contract documents shall be:

D. Mohawk cable

E. The manufacturer of the fiber optic cabling products specified in this document, as required for construction of the Fiber Optic cable per contract documents shall be:

F. Mohawk cable OR EQUAL

G. Product substitutions are permitted under the conditions stated below. (1.7 A)

1.7 PRODUCT SUBSTITUTIONS

A. Product substitutions from other manufacturers shall require the approval of the owner or owner's representative.

1.8 QUALITY ASSURANCE

A. Installed category 6 balanced UTP and fiber cabling systems, pathways and distribution facilities shall adhere to manufacturer's instructions, contract drawings and specifications, and applicable codes, standards and regulations.

B. Installed category 6 balanced UTP cabling systems and field test results shall strictly adhere to requirements of ANSI/TIA/EIA-568-C.0 and ANSI/TIA/EIA-568-C.2.

C. Installed optical fiber cabling systems and field test results shall strictly adhere to requirements of ANSI/TIA/EIA-568-C.0 and ANSI/TIA/EIA-568C.3.

D. Where applicable, all equipment, components, accessories and hardware shall be UL listed for the intended purpose of the installation.

E. Installed products shall be manufactured by an ISO 9001 certified facility.

F. Installed products shall be free from defects in material or workmanship from the manufacturer, and shall be of the quality indicated.

G. All methods of construction that are not specified in the contract documents shall be subject to control and approval by the Owner or Owner's Representative.

H. Installed products shall be lot-traceable by date code.

I. All critical internal manufacturing operations for installed products shall have documented in-process inspection and testing according to ISO9001.

1.9 DRAWINGS

A. Approved or preliminary contract drawings furnished at the time of bid solicitation shall serve as the basis for product selection, creation of bills of material, and determination of labor content.

B. Changes, additions, or deletions to contract drawings prior to awarding of the contract, shall require an amendment to the original bid.

C. Prior to submitting the bid, in reviewing the contract drawings, the Approved Contractor shall:

D. Request the attention of the Engineer, Owner, or Design Agency to clarify any materials, apparatus or work believed to be incorrect, inadequate, omitted, or in violation of applicable codes, standards or regulations.

E. Note any contingencies related to unknown aspects of any drawings or specifications.

F. Contract drawings, prior to execution of the project, shall be formally approved and released by the Engineer or Design Agency, and shall be approved by the Owner or Owner's Representative.

G. Execution of work shall be according to approved drawings, in addition to applicable specifications and contractual obligations.

1.10 APPLICABLE STANDARDS, CODES, AND REGULATIONS

A. Installation Standards: Cable installation shall comply with the following:
   1. American National Standards Institute, (ANSI)

2. ANSI/TIA-568-C.0, "Generic Telecommunications Cabling for Customer Premises", published 2009
3. ANSI/TIA-568-C.1, "Commercial Building Telecommunications Cabling Standard", published 2009
4. ANSI/TIA-568-C.2, "Balanced Twisted-Pair Telecommunication Cabling and Components Standard", published 2009
5. ANSI/TIA-568-C.3, "Optical Fiber Cabling Components Standard", published 2008, errata issued in October, 2008
6. ANSI/TIA-568-C.4, “Coaxial Cabling Component Standard” Published 2010
7. ANSITIA/EIA-569-B, Commercial Building Standards for Telecommunications Pathways and Spaces, 2003.
8. ANSI/tia-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications, 2010.
9. ANSI/TIA/EIA-942, Telecommunications Infrastructure for Data Centers, 2004.
10. ANSI/ICEA S-83-596, Fiber Optic Premises Distribution Cable, 2001.
11. ANSI/TIA/EIA-598, Color Coding of Optical Fiber Cables, 2001
12. ANSI/ICEA S-87-640, Fiber Optic Outside Plant Distribution Cable, 1999.
13. ANSI/TIA/EIA-492AAAC, Detail Specification for 850nm Laser-Optimized 50um Core Diameter/125 um Cladding Diameter Class 1A Graded Index Multimode Optical Fibers, 2003.
14. ANSI/TIA/EIA-492CAAA, Detail Specification for Class Iva Dispersion-Unshifted Singlemode Optical fibers, 2002.
15. ANSI/TIA/EIA-758: Customer-Owned Outside Plant Telecommunications Cabling Standard, 2004.
16. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Plant: OFSTP-7, 2002.
17. ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Plant: OFSTP-14A, 2003.
18. ANSI/TIA/EIA-TSB-125, Guidelines for Maintaining Optical Fiber Polarity Through Reverse-Pair Positioning, 2001.
19. ANSI/TIA/EIA-TSB-140, Additional Guidelines for Field Testing Length, Loss, and Polarity of Optical Fiber Cabling Systems, 2004.
20. ANSI/TIA/EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure, 2002.
21. ANSI/EIA-310-D, Cabinets, Racks, Panels, and Associated Equipment, 1992.
22. ANSI/TIA/EIA-604 (Series), FOCIS Fiber Optic Connector Intermateability Standard, 2000-2003.
23. National Fire Protection Association, Inc., NFPA 70
24. National Electric Code (NEC), 2005.
25. NEC Article 250: Grounding

26. NEC Article 386: Surface Metal Raceways
27. NEC Article 388: Surface Non-Metallic Raceways
28. NEC Article 800: Communications Circuits
29. NEC Article 770: Optical Fiber Cables and Raceway
30. Underwriter's Laboratory, Inc. (UL)
31. UL-5A: Standard for Non-Metallic Raceways and Fittings
32. UL-5: Standard for Surface Metal Raceways and Fittings
33. UL-5C: Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits
34. UL-50: Standard for Enclosures for Electrical Equipment
35. UL-94-V0: Tests for Flammability of Plastic Materials
36. UL-498: Attachment Plugs and Receptacles
37. UL-1479: Fire Tests of Through-penetration Firestops (in Accordance with ASTM E814).
38. UL-1863: Standard for Safety of Communications Circuit Accessories
39. National Electrical Manufacturer's Association (NEMA)
40. ANSI/NEMA WD-6-2002: Wiring Devices – Dimensional Requirements
41. NEMA 250-2003: Enclosures for Electrical Equipment
42. ISO/IEC 11801, Ed. 2:2002, Information Technology – Generic Cabling for Customer Premises, 2002.
43. ISO/IEC 18010, Information Technology – Pathways and Spaces for Customer Premises Cabling, 2005.
44. ISO/IEC 14763-1, Information Technology – Implementation and Operation of Customer Premises Cabling – Part 1: Administration, 2004.
45. CSA C22.1-06, Canadian Electric Code (CEC), 2006
46. Federal Communications Commission (FCC) Title 47, Code of Federal Regulations, Part 68: Connection of Terminal Equipment to the Telephone Network, 1998.
47. U.S. Public Law 336. 101st Congress, ADA: Americans with Disabilities Act of 1992.
48. IEEE 802.3af, Data Terminal Equipment (DTE) Power Over Media Dependent Interface (MDI), 2003.
49. IEEE 802.3at (current draft), Data Terminal Equipment (DTE) Enhanced Power Over Media Dependent Interface (MDI).
50. IEEE 802.3ae, Specification for 10 Gbit/s Ethernet Operation over Optical Fiber.
51. Telecommunications Distribution Methods Manual, 11th Ed., Building Industry Consulting Services International (BICSI), 2006.
52. Information Transport Systems Installation Manual, 4th Ed., Building Industry Consulting Services International (BICSI), 2004.

B. This document is not a substitute for any code, standard or regulation. The Approved Contractor must be aware of local codes that may impact the bid submittal or execution of the project. The current revision of any applicable code, standard, or regulation shall take precedence at the point of project execution, unless otherwise recognized by local authorities. Applicable standards or codes that affect construction, which are listed as normative references within any governing document, are also the responsibility of the Approved Contractor for compliance.

C. Materials:

1. All materials shall be UL or ETL listed and verified and shall be marked as such.

2. Products shall be regularly catalogued items of the manufacturer and shall be supplied as a complete unit in accordance with the manufacturer's standard specifications with any optional items required for proper installation unless otherwise noted.

3. Material shall be delivered to the site in the original packing.

1.11 MAINTENANCE

A. All materials used on this project shall be new. Used and refurbished equipment is not permitted unless approved by CITY OF MADISON. Provide equipment to site in original packaging whenever practical.

B. The Contractor is responsible for scheduling all deliveries and providing proper receipt, handling, and storage of all materials. Protect all equipment from physical damages (dents, scratches, dust, water, paint, chemicals, and temperature extremes) and vandalism, or theft. The Contractor shall replace any damaged or stolen equipment. The Contractor is responsible for all equipment until final project acceptance by Owner.

C. Maintenance of the cabling infrastructure is to be done by authorized personnel only, or void of manufacturer’s warranty may result. It is the responsibility of the owner or end user to utilize a certified installer to maintain warranty coverage on existing or new cabling infrastructure.

D. The telecommunications contractor shall furnish a quotation for time and material to perform maintenance and repairs. The owner has the first right of refusal of selecting a suitable contractor or qualified internal personnel to perform maintenance and repairs on structured cabling.

E. Additions of new cabling, either horizontal or backbone, shall be completed, tested, and documented into permanent building records. New cabling installations intended to be covered by the manufacturer’s warranty shall adhere to the documentation submittal and system certification provisions stated above.

F. The Contractor is responsible for cleaning the worksite every business day and remove debris from the facility.

1.12 DOCUMENTATION

A. TEST RESULTS

1. All test results are to be saved electronically on CD. Test documentation submitted on disk shall be clearly marked on the cover with the words “Project Test Documentation”, the project name, and the date of completion (month and year). For multiple buildings, the building name, including floor or wing I.D. should also be included on the test results disk.

2. File names of the test results recorded for each link shall match the official identification. Test results shall include a complete record for each link, including

type of test, cable type, cable/port I.D., measurement direction, reference setup, date, and technician's name(s).

3. The test equipment name, manufacturer, model number, serial number, software version and last calibration date shall also be provided in the test results documentation.

4. When repairs and re-tests are performed, the problem cause and corrective action taken shall be noted, and both the failed and passed test data shall be documented.

5. The owner, engineer, lead project manager, or owner's representative reserve the right to request verification of test results with a re-test of installed cables, on a sampling basis. Re-testing shall be at the expense of the installer unless otherwise noted in the contract documents.

B. AS BUILT DRAWINGS

1. Deviations from the approved drawings, whether or not a change order is submitted, shall be clearly denoted as built on the working hard copy drawing by the telecommunications contractor. As-built drawings shall be returned promptly to the owner or design agent for completion of drafting revisions to the original design. See "Documentation – Change Orders" below. Manufacturer's warranty registrations may also require as-built drawings.

2. Floor plan drawings shall at minimum include detailed cable and pathway layouts, exact locations of workstation outlets, and cable distribution hardware locations. Workstation outlets shall have alphanumeric identifiers on the drawings as specified by the end user or owner.

C. CHANGE ORDERS

1. Any deviation from the approved contract drawings or specifications shall be submitted as a written change order.

2. Execution of work, to perform changes, shall not proceed without prior written approval. Any changes done without written approval will be at no cost to CITY OF MADISON. If the work is shown to be incorrect the contractor will have to correct the problem at no cost to CITY OF MADISON.

3. Significant changes may require a written quotation of additional labor and materials from the telecommunications contractor.

4. It is the responsibility of the owner or owner's representative to bear the added cost of any substantial cabling system design changes. The contractor will not proceed with any change orders without written approval by the owner's representative. Any changes not approved by the owner's representative will be responsibility of the contractor and at no cost to CITY OF MADISON.

5. Field changes that are completed without issuance of revised drawings shall be clearly denoted on the working as-built drawing. Refer to "As-Built Drawings" above.

D. PUNCH LISTS AND CORRECTIVE ACTION

1. As required in the contract documents, the telecommunications contractor shall correct punch-lists items determined to be in violation of drawings, specifications, codes, standards or regulations.

2. The contractor shall be responsible for timely re-work of faulty cabling or hardware installations.

3. The owner reserves the right to withhold final payment until punch list items are resolved satisfactorily.

1.13 WARRANTY

A. THE CITY OF MADISON requires a Permanent Link warranty for the project. Manufacturer requires Permanent Link Test.

B. The length of the extended warranty shall be a minimum of twenty-five (25) years.

C. Warranty covering all components, equipment and workmanship shall be submitted in writing with system documentation.

D. The warranty period shall begin on the system's first use by the owner.

E. Should the cabling system fail to perform its expected operation within this warranty period due to inferior or faulty material and/or workmanship, the contractor shall promptly make all required corrections without cost to the Owner

F. Upon Completion of the project the Telecommunication Contractor shall forward the signed Warranty Registration Form and warranty certificate to the Owner.

G. The manufacturer warrants category 6 cabling, optical fiber cabling and connecting components free of defects in material or workmanship.

H. Category 6 and optical fiber cabling and components are warranted to perform the intended application upon completion of proper installation and testing.

I. Warranty coverage includes application assurance and compliance to applicable performance specifications.

J. Installed category 6 cabling systems may be granted a full Channel warranty under the conditions stated below.

1. A certified installer registered who has completed a Manufacturer’s training program performs the construction.

2. Contractors performing the certified installation are properly registered in the Manufacturer’s warranty program.

3. The channel components are supplied entirely by one Manufacturer, including patch cords.

4. Cable used in the installation is qualified and recognized by Connectivity Manufacturer.

5. Installed link systems are properly documented and tested with a “PASS” result. The county requires a link test and the use of manufacturer patch cords to receive a channel warranty.

6. Field test equipment used for category 6 cabling is minimum level III classification, and complies with TIA/EIA-568-B.2 requirements.

7. Required test results, stored on a CD, and project documentation including as-built drawings, are to be submitted to the Manufacturer by the registered contractor.

1.14 MOVES, ADDS AND CHANGES

A. Moves, additions and changes initiated by the owner, end user, project manager, or design agent, which are beyond the scope of work in the original contract, shall require a revised quotation by the telecommunications contractor.

B. It is the responsibility of the owner or owner's representative to bear the added cost of any substantial cabling system design changes.

C. Moves, additions and changes shall either be issued in revised drawings, or otherwise shall be clearly denoted on as-built drawings.

D. Moves, additions and changes that affect installations covered in a manufacturer's warranty shall be performed by a certified contractor that is properly registered in the manufacturer's warranty program.

1.15 CLEANUP

A. The communications Contractor shall clean up all debris related to this work on a regular basis leaving the job site in a clean, safe condition.

B. Protect all equipment from damage during construction. Equipment not protected shall be replaced at the Contractor's expense.

PART 2 PRODUCTS

2.1 WORK AREA CONNECTORS

A. Category 6 Jacks

1. Jacks shall be standard 8-position, RJ-45 style, un-keyed, FCC compliant.
2. Jacks shall be designed for 4-pair, 100 ohm balanced unshielded twisted pair (UTP) cable.
3. Jacks shall terminate 26-22 AWG solid or stranded conductors.
4. Jacks shall include a dust cap for wire retention.
5. Jacks shall accept FCC compliant 6 position plugs.
6. Jacks shall have attached wiring instruction labels to permit either T568A or T568B wiring configurations.
7. Category 6 jacks shall be backward compatible with existing Category 3, 5, and 5e cabling systems for fit, form, and function.
8. Jacks shall be manufactured in the USA.
9. Category 6 jacks shall meet or exceed Category 6 transmission requirements for connecting hardware, as specified in ANSI/TIA/EIA-568-C.2, Transmission Performance Specifications for 4-Pair 100 ohm
10. Jacks shall be UL LISTED and CSA certified.
11. Colors to specified by end user
12. Category 6 modular jacks, as specified in the Contract Documents, shall be:
13. Hubbell
14. HXJ6EI (Category 6 - ivory)

2.2 FACE PLATES

A. Rear loading w/designation window

1. Faceplates shall be constructed of high impact, UL94 V-0 rated thermoplastic.
2. Faceplates shall be compatible with standard NEMA openings and boxes.
3. Faceplates shall be 2.75" W x 4.5" H (69.8 mm x 114.3 mm) for single gang and 4.5" X 4.5" (114.3 X 114.3 mm) for double gang.

4. Port size in each faceplate shall fit the Category 6 Modular Jack or Snap-Fit fiber optic, audio, and video modules for multimedia applications.

5. Faceplates shall be provided with clear plastic and color-matched label field covers. Faceplates shall provide for ANSI/TIA/EIA-606-A compliant workstation outlet labeling.

6. #6-32 pan head Phillips/slotted mounting screws shall be included with each faceplate.

7. Faceplates shall be UL LISTED and CSA certified.

8. Work area faceplates, as specified in the Contract Documents, shall be

9. Hubbell (IFP Series)

10. IFP14ei (4-port ivory)

2.3 CABLE

A. Category 6 UTP

1. Plenum - Cable construction shall be four twisted pairs of 23 AWG insulated solid conductors, with a ripcord, surrounded by a tight outer jacket.

2. Non-plenum - Cable construction shall be four twisted pairs of 24 AWG insulated solid conductors, with a ripcord, surrounded by a tight outer jacket.

3. NO minimum compliant cable will be accepted. The facility requires additional bandwidth.

4. Ripcord shall be directly underneath the outer jacket.

5. Cable shall be marked with Manufacturer and pertinent information. UL, ETL, or CSA agency certification or verification markings shall be marked on the cable jacket according to the certifying agency's requirements.

6. Color coding of the pairs shall be as follows:

7. Pair 1: White/Blue; Blue

8. Pair 2: White/Orange; Orange

9. Pair 3: White/Green; Green

10. Pair 4: White/Brown; Brown

11. Plenum or Riser rated jackets

12. Cable shall be supplied in 1000 ft spools or 1000 ft Reelex boxes.

13. Cable shall exceed Category 6 transmission requirements specified in ANSI/TIA/EIA-568-C.2.

14. Cable shall be UL and C (UL) listed.

15. Cable shall exceed the requirements of TIA/TSB-155: 10 Gb/s Ethernet Operation over 37 Meters Channel Length.

16. Category 6 UTP horizontal distribution cable, as specified in the Contract Documents, shall be

17. Mohawk advancenet cable

18. Plenum m57193

19. Riser M57202

B. Backbone distribution cable – Fiber Optic

1. Singlemode fiber backbone distribution cable shall be available in multi-strand constructions for intra-building applications.

2. OFNR or OFNP will be determined at each site. The contractor will be responsible to assure that the proper type of jacketing is being used. Failure to meet the local code will be cause for replacement of cable at no expense to CITY OF MADISON.

3. Singlemode fiber shall be dispersion un-shifted fiber in compliance with ANSI/TIA/EIA-492CAAA.

4. Intra-building fiber distribution cable design shall be according to ANSI/ICEA S-83-596.

5. Singlemode backbone fiber distribution cable, when installed, shall exceed the performance requirements of ANSI/TIA/EIA-568-C.3.

6. Singlemode optical fiber Backbone Fiber distribution cable, as specified in the Contract Documents, shall be

7. Mohawk cable (basis of design) or equal

8. Singlemode riser m9w042 (12 strand) – unless otherwise specified by THE CITY OF MADISON.

9. Singlemode plenum M9w048 (12 strand) - unless otherwise specified by THE CITY OF MADISON.

2.4 CONNECTORS – FIBER OPTIC

A. Pre-polished fiber connector basic design shall be a factory pre-polished lc-style optical fiber connector with a zirconium ceramic ferrule.

B. Index-matching gel is factory-injected into the cleaved fiber stub splice to minimize connector insertion loss.

C. lc Singlemode factory pre-polished connectors shall HAVE pre-installed fibers.

D. Connector materials shall be designed with thermal stability to comply with environmental requirements of ANSI/TIA/EIA-568-B.3 and Telcordia GR-1081-CORE.

E. Pre-polished lc connectors shall require no field polishing AND REQUIRE NO ADHESIVES FOR TERMINATION.

F. Connector design and termination technique shall be independent of cable type or manufacturer, and shall be compatible for either 900 micron buffer or 250 micron buffer distribution cables.

G. Pre-polished Lc fiber connectors, when properly installed onto qualified cable, shall meet the 10 Gb/s Ethernet performance requirements of IEEE802.3.

H. lc fiber connectors, properly installed onto qualified cable, shall exceed the mechanical and environmental performance requirements of ANSI/TIA/EIA-568-C.3.

I. Multimode optical fiber horizontal distribution cable, as specified in the Contract Documents, shall be

1. Hubbell (ProClick)

2. Singlemode LC - FCLC900Ksm12

3. AFL (fast)

4. Singlemode lc – fast-lc-sm

2.5 PATCH PANELS – CATEGORY 6

A. Category 6 patch panels shall be standard 8-position, RJ-45 style, un-keyed, FCC-compliant receptacle, in 24- and 48-port configurations.

B. Panel frames shall be black powder coated 14-gage steel with rolled edges top and bottom for proper stiffness.

C. Panels shall accommodate a minimum of 24 ports for each rack mount unit (1 RMU = 1.75 in.). 48 ports are recommended.

D. Panels shall be designed for 4-pair, 100 ohm balanced unshielded twisted pair (UTP) cable.

E. Panels shall terminate 26-22 AWG solid conductors.

F. Panels shall have individual port identification numbers on the front and rear of the panel. Panels shall have the Category 6 designation, visible from the front when installed.

G. Printed circuit boards shall be fully enclosed front and rear for physical protection.

H. Panel contacts shall accept a minimum of 2000 mating cycles without degradation of electrical or mechanical performance.

I. Panel termination method shall follow the industry standard 110 IDC punch-down, using a standard 110 impact termination tool.

J. Category 6 panels shall be backward compatible with existing Category 3, 5, and 5e cabling systems for fit, form, and function.

K. Category 6 patch panels, when installed, shall exceed the link or channel performance requirements of ANSI/TIA/EIA-568-C.2.

L. Category 6 patch panels shall BE able to accommodate 10G in a 37 meter channel per TSB-155.

M. Category 6 patch panels, as specified in the Contract Documents, shall be:

1. Hubbell (NEXTSPEED 6 Series)

2. 24 Port - P6E24U

3. 48 Port - P6E48U

2.6 RACKS – FREE STANDING – 2 POST

A. Rack material shall be STRUCTURAL ALUMINUM with a durable black polyurethane powder coat finish.

B. Installed racks shall have a static load capacity of 500 Lbs.

C. Racks shall be available in either 19-inch or 23-inch standard rack configurations.

D. Tapped holes in the vertical rails for mounting of panels shall be #12-24 thread size. Coating shall not interfere with thread fit.

E. Standard rack heights OF 7 ft (84 in), and have a capacity of 45 RMU.

F. Rack base angles shall be pre-drilled for floor mounting, and for assembly to vertical rails.

G. Each Rack shall be provided with, Racks shall accommodate expansion of cable capacity and added volume FOR CATEGORY 6 cabling.

H. *NOTE:* Each basic rack delivered shall consist of: Equipment Rack, Isolation pads, 18" wide Black Ladder Rack & mounts to secure to Rack, a vertical Electrical 20 amp Outlet strip (Minimum 6 receptacles) with Mounting Brackets.

I. Free standing racks and accessories, as specified in the Contract Documents, shall be:
   1. Hubbell (NextFrame series)
   2. HPW84RR19

2.7 CABLE MANAGEMENT –VERTICAL CABLE MANAGEMENT

A. Z-channel design offers:
   1. Airflow
   2. Minimizes weight
   3. Maximum cable capacity with unobstructed access to cable

B. Snap in Spools with ability to put them where they will do the most good

C. Rear cable management allows cable to be run on both left and right sides, while leaving the area behind the electronics and patch panels open for increased airflow

D. Construction:
   1. Cold Rolled steel z-channels
   2. Cold rolled steel covers

E. Mounts to 84" Equipment racks

F. Channel width: 6"W

G. Vertical Cable Management and accessories, as specified in the Contract Documents, shall be:
   1. Hubbell (NEXTFRAME series)
   2. VS76

2.8 CABLE MANAGEMENT – HORIZONTAL

A. Horizontal management will be constructed of 14 ga cold-rolled steel (CRS)

B. Finish shall be a Durable, black powder coat.

C. Size: 2RU

D. Front Ring Depth: 3.5"

E. All steel construction - rugged, non-flammable, no fasteners to wear or break, no fingers to fuss with.

F. Modular components easily configured in field to adapt to demanding applications.

G. Hinged Front Cover - Locks in place when completely open to prevent cover from being removed or lost.

H. Horizontal Cable Management and accessories, as specified in the Contract Documents, shall be:
   1. Hubbell (NEXTFRAME series)
   2. HC219ce3n

I. Enclosures – fiber rack mount
   1. Rack-mounted, powder coated formed cold rolled steel enclosure.

2. Swing-out or pull-out inner tray shall provide access to inner cables and connections, and maintain proper cable bend radius throughout the range of motion.

3. Fiber rack-mount enclosures shall be a 19-inch formed/welded and powder coated modular design, sized according to the cable installation.

4. Fiber rack-mount enclosures may serve as a main, horizontal, or intermediate cross connect facility.

5. Panel mounting brackets shall be configurable to either 19" or 23" racks per ANSI/EIA-310-D.

6. Enclosure chassis shall have two mounting bracket locations for either flush mount or center mount on the rack.

7. Inner tray shall have a threaded mounting boss to accept a mounting stud for splice trays. Splice tray capacity shall be (2) 10" splice trays, each with 24-splice capacities (48 splices total). Splice tray mounting boss shall also accept a stud for mounting 1-RMU blown fiber adapter brackets.

8. Inner tray mounting posts for modular panels shall also accept 12-fiber MTP-style cassettes for "plug & play" installations.

9. Inner tray shall have rear cable tie-down features to accept various diameter backbone cables entering the enclosure.

10. Enclosures shall be constructed of 16 gage cold rolled steel (CRS)

11. Fiber rack-mount enclosures and accessories, as specified in the Contract Documents, shall be:

12. Clearfield – fieldsmart fiber crossover distribution system.

J. Adapter panels – optical fiber

1. Optical fiber Adapter panels shall be a modular design powder coated stamped metal construction.

2. ADAPTER PANELS SHALL BE LC.

3. High or low-density versions.

4. Adapter panels shall have quick-release snap fasteners to fit directly into fiber enclosures.

5. Fiber patch panels, as specified in the Contract Documents, shall be:

6. clearfield – clearview class patch only cassette.

2.9 INNER-DUCT

A. Fiber Optic Cable shall be installed with Innerduct for protection of fiber cables in a shared pathway

B. The inner duct will be rated for the environment that it is being installed in. Plenum and riser rated

C. Three inner Ducts will be run between closets. One for current installation, two spare for future applications.

D. Size: 1" CORRUGATED

E. Flexible & Lightweight for ease of handling

F. Pre-threaded with pull line

PART 3 EXECUTION

3.1 APPROVED CONTRACTOR RESPONSIBILITIES

A. The Approved Contractor shall assume the following responsibilities:

1. Execute construction in accordance with contract drawings and specifications.
2. Adhere to project schedules and job site rules.
3. Adhere to the quality, regulatory, logistics, and documentation requirements.
4. Adhere to the product requirements outlined in PART 2 above.
5. Adhere to the Execution guidelines outlined below.
6. Furnish the cabling system certification and warranty provisions outlined in this specification section.

3.2 DELIVERY, STORAGE AND HANDLING LOGISTICS

A. Materials delivered to the construction site shall be stored in a dry, secure area, preferably indoors. Storage temperature of materials shall adhere to manufacturer's recommendations. Movement of packaged materials shall be in a manner to avoid damage of contents. On-site storage, either indoors or trailer, shall have permission by the owner, and shall not interfere with other construction activity.

B. Installation of category 6 cable shall be within the recommended temperature range specified by the manufacturer. Cable installation temperature above 50F is recommended.

3.3 PREPARATION

A. Cable pathways and Firestops

1. Cable pathways, including conduit, cable tray, ladder rack, raceway, slots, sleeves, etc. shall be located and mounted according to contract drawings and manufacturer's instructions. Pathways shall not be installed in wet areas.
2. Cable pathway fill ratio, bend radius, run length, number of bends, and proximity to EMI sources shall be in accordance with ANSI/TIA/EIA-569-B. Maximum cable count of the initial installation shall not exceed 40% fill ratio in any pathway.
3. In accordance with NEC 2005, power wiring and communications cabling shall not share the same pathway or outlet unless separated by a physical barrier.
4. Cable pathways shall be secured to a structural member of the building, or permanent wall studs. Wall surfaces for raceway mounting should be finished complete.
5. Metallic pathways shall be electrically continuous, free of sharp edges, and properly bonded to an approved ground. EMI sources such as ballasts, motors, and bus conductors shall be avoided by using proper separation distances.
6. Pathways that penetrate fire-rated barriers shall be fire stopped according to local codes and recognized practices. Fire stop materials or devices shall be qualified to UL-1479, in accordance with ASTM E814. Fire stop method shall have P.E. approval.
7. Core drilling of holes for fire-rated poke-through outlet devices shall have approval by a structural engineer or P.E. on the contract drawings prior to start of work.

8. Pathways for vertical cable runs, such as slots and sleeves, shall be installed in the proper location in accordance with applicable codes and standards.

B. Telecommunications rooms and equipment rooms

1. Telecommunications room (TR) layout, location and design shall be in accordance with the guidelines of ANSI/TIA/EIA-569-B. TR's on each floor of the building should be centrally located and vertically aligned to simplify backbone cable and pathway routing. TR's shall not be installed in wet areas, or near EMI sources or caustic chemicals.

2. Layout of rack, cabinet or enclosure locations shall be according to contract drawings.

3. Racks and cabinets shall be secured to the floor using proper anchors and fasteners.

4. Mount and assemble racks, cabinets, brackets and enclosures per manufacturer's instructions. Mount patch panels and cable management accessories in the specified locations.

5. Adjoining pathways (ladder rack, cable tray, etc.) shall be properly secured and positioned to allow adequate bend radius of cables entering the rack or cabinet.

C. Wall outlets and recessed wall Boxes

1. Wall outlet and cable drop pathway location shall be according to contract drawings. Guidelines from ANSI/TIA/EIA-569-B should be followed for location with electrical outlets and outlet height above finished floor.

2. Outlet boxes shall be fastened securely to a wall stud or structural element, in a manner to permit flush mounting of the faceplate with the finished wall.

3. Multi-connect boxes shall be installed in a manner to comply with separation rules for power and communications wiring in close proximity.

4. Refer to specific manufacturer's recommendations for wall outlet selection, cable deployment, and termination of jacks into faceplates.

D. Surface housings and MUTOA outlets

1. Raceway or conduit should be deployed to the surface housing location. For through-wall cable entry, cut the wall opening to match the opening in the housing base.

2. Lay out mounting holes onto the desired wall location. For wallboard, concrete or cinder block walls, drill to the proper depth and install anchors.

3. Always use proper wall anchors. Installing mounting screws directly into wallboard without using anchors can cause screw pullout and detachment of the surface housing. Mounting the base plate to studs is recommended.

4. Mount base plate of surface box or MUTOA to outlet location using proper fasteners. Note: furniture and wall outlet applications require mounting of base plate prior to cable pulling and connector termination.

5. Install cover onto base plate.

6. Refer to detailed manufacturer's guidelines for cable deployment and termination of jacks into surface housings. Due to the larger size of category 6 cables, proper cable bend radius must be maintained. Certain restrictions may apply when dressing category 6 cabling into surface housings.

3.4 INSTALLATION

A. Cable Support

1. This Contractor shall install all supports for cables specified in this section. Traditional Ladder rack will be used in each telecommunications room, basket tray and j-hooks will be used in the horizontal.

2. Cable supports shall be spaced randomly, but no further than 5'-0" apart.

3. Inner-ducts will be run between each closet or telecommunications room. One for current installation with three multi cells for future installations or changes. In each telecommunications room the inner-ducts entering the space will be combined, in a size appropriate metallic box that is mounted on the wall. The combined inner ducts will then be routed to the rack and the fiber bay.

4. Provide all additional cable management products, sleeves or conduit raceways as required to protect exposed cabling and complete the installation of cables in a neat manner.

5. A horizontal conduit system consists of conduits radiating from the telecommunications room to the workstation outlets in the floor, walls, ceilings, and columns of a building. When using a conduit distribution system utilize the most direct route following the building lines.

6. The size and number of conduits or sleeves used for backbone pathways depends on the usable floor space served by the backbone system. at least three 4 trade size sleeves are recommended.

7. Conduit is only required if building codes or environmental conditions necessitate it. Rigid or EMT metal conduits are deemed suitable for building installation. Adequate planning should allow for a minimum of one 1-inch conduits to each workstation location if code requires conduit for voice and data cables.

8. Conduit fill ratios shall not exceed 40%; contact your cable manufacturer to get recommendation on fill rates.

9. No conduit run should be designed with more than two (2), 90 degree bends between pull points or pull boxes. If a run requires more than two 90 degree bends, install a pull box.

   a Exceptions:

      i. The total run is not longer than 33 ft.

      ii. The conduit size is increased to the next trade size.

      iii. One of the bends is located within 12 in of the cable feed end. (This exception only applies to placing operations where cable is pushed around the first bend.)

10. All conduits will be equipped with a contiguous length of plastic or nylon pull string with a minimum rating of 200 lbs. (90 Kg)

11. A conduit run should not be designed with continuous closed sections longer than 100 ft without pull points or pull boxes installed.

12. All conduits should terminate above or in the installed ladder racks and allow for proper cable racking. Cable waterfalls should be considered in areas that have excessive distance between the conduit and ladder rack.

13. Trays and conduits located within the ceiling shall protrude into the room a distance of 1 to 2 in without a bend and above 8 ft high. Clear, unobstructed access to the ladder rack and conduits shall be provided within telecommunications rooms.

14. Conduits entering through the floor shall terminate at least two (2) inches above the finished floor

15. Locate slot/sleeve systems in places where pulling and termination will be easy.

16. If possible, locate sleeves, slots, and/or conduits on the left side of the room; this placement enhances the use of wall space from left to right.

17. When possible, entrance conduit and distribution conduit/cable tray should enter and exit on the same wall; if this is not possible, ladder rack inside the room should be provided for distribution from wall to wall.

18. All floor penetrations shall be core drilled with a maximum 1/4 inch size greater than the exterior dimension of the riser conduit

19. Conduits entering through a wall shall be reamed and bushed, and terminated as close as practicable to the terminating rack or wall

20. Terminating above a suspended ceiling must terminate not less 3 inches above finished ceiling and finished with bushing opening.

21. All conduit will be labeled for easy identification

22. All floor penetrations shall be at columns, exterior walls or in equipment rooms.

23. Cables shall be supported at height of bottom flange of structural beams using a rigid support method (i.e. threaded rod, beam clamps, etc.)

24. Do not support cables from ductwork, sprinkler piping, water piping, waste piping, conduit, ceiling wire, or other system supports.

25. The conduits or sleeve will be installed per TIA/EIA-569-B and seal all penetration with approved fire stop product.

26. Provide independent support system for each low voltage cabling system.

B. Cable:

1. Category 6 cable will be run for data. Category 6 Gelled filled cable will be run in the backbone for all communications applications. Certain environments may require the use of different cables and/or cable jackets.

2. **All Terminations will utilize T568B wiring in THE CITY OF MADISON facility.** Any Contractor not complying with this wiring requirement will fix the problem at no cost to CITY OF MADISON.

3. Maximum cable lengths to be 295 feet (90 m) including service loop. Provide all necessary installation materials, tools and equipment to perform insulation displacement type terminations at all communications outlets, patch panels.

4. All communications cabling that has become abandoned as part of new renovation projects, previous renovation projects, or temporary communication cables used during the construction process shall be completely removed.

5. Refer to detailed manufacturer's guidelines for deployment of category 6 cable. Certain restrictions apply, and specific techniques are recommended.

6. All cabling shall be installed in accordance with manufacturers' written bend radius and pulling tensions. General industry guidelines recommend the following bend radius and pulling tensions:

7. Tensile loading on a single 4-pair copper UTP cable shall not exceed 25 lbf.

8. Bend radius of a single 4-pair copper UTP cable shall not exceed 4 times the diameter of the cable.

9. Bend radius of multi-pair copper UTP and optical fiber cable shall not exceed 10 times the diameter of the cable.

10. All conduits and conduit sleeves shall have bushings or grommets shall be installed prior to the installation of communications cables to avoid damage and abrasions to cable sheathing and insulation. If bushings have are installed by the electrical Contractor, the communications cabling contract shall furnish and install bushings prior to pulling communications cabling.

11. Horizontal cable length for 4-pair copper UTP cables shall not exceed 295 feet. Prior to bidding and installation, the contactor shall review the drawings and verify no cable run exceeds 295 feet and notify the communications designer of cable runs that may exceed 295 feet.

12. Splices are not permitted in any voice or data cable unless other specified or shown on drawings.

13. Avoid placing copper cables near sources of extreme heat (i.e. boilers, radiators, heat coils).

14. Maintain cable twists for all UTP cables. For terminations cable sheathing shall be stripping back no more than ½" back from termination point for all Category 6 cables.

15. All cables shall be supported by cable tray, cable runway, or J-hooks. When large quantities of cables leave trays or runways, cables shall be supported by drop-outs or cable support hardware manufactured specifically for the purpose of supporting cables. J-hooks shall be installed a minimum of every 5 feet and cabling shall maintain minimal deflection and strain (less than 12" deflection). Cables shall not be supported from ceiling grid wires. Cables shall not run above iron joists.

16. All cables shall be separated and bundled into like groups.

17. Service loops shall be provided at both ends of installed horizontal and backbone cabling. A 12" service loop shall be installed in the ceiling space near workstation outlets (excessive cable shall not be coiled in outlet boxes). A 10' service loop shall be provided in communication rooms and shall be installed to allow for future equipment rack/cabinet relocations without the need to re-terminate patch panels; the 10' service loop shall be neatly bundled and secured in ceiling space with large D-rings or place in cable trays. Cable slack and service coils shall be stored properly above the ceiling or under the access floor. A "figure-eight" service loop is recommended for category 6 cabling to reduce EMI coupling. Loose, random bundling is recommended.

18. Any cabling installing in equipment rooms shall be neatly placed in cabling trays, cabling runways, or horizontal and vertical rack/cabinet cable managers

19. Velcro straps shall be utilized in the TR and inside TC enclosures for all cable bundling. Tie wraps shall be prohibited in the telecommunication rooms.

20. Separation: Maintain the following distances between cables, other system cables and other building systems:

21. One (1) foot from fluorescent lights.

22. One (1) Foot from Power cable in Parallel

23. One (1) foot from electrical conduits, other systems cables or other electrical equipment.

24. Four (4) feet from motors and transformers

25. Three (3) feet from hot water piping or other mechanical equipment.

26. Ten (10) Feet from Bus Conductors or High-Current branch circuits

27. All low voltage cables shall be run parallel or at right angles to building structural framework. Do not run cables diagonally across ceiling space without written authorization by the Architect's Electrical Engineer or CITY OF MADISON Representative.

28. Communications cabling that must cross power cables or conduit shall cross at a 90-degree angle, and shall not make physical contact.

29. Fire seal around all cables running through rated floors and walls. Firestop all cables and pathways that penetrate fire-rated barriers using approved methods and according to local codes.

30. Leave spare pull string with every outlet installed.

31. Do not install cable in wet areas, or in proximity to hot water pipes or boilers.

32. Cable ends for termination shall be clean and free from crush marks, cuts, or kinks left from pulling operations. Installed cable jackets shall have no abrasions with exposed conductor insulation or bare copper "shiners". The installer is responsible to replace damaged cables.

33. Backbone cables shall be installed and bundled separately from horizontal distribution cables. Backbone and horizontal cable bundles shall be loose and random.

34. Backbone cables spanning more than three floors shall be supported at the top of the cable run with a wire mesh grip and on alternating floors, unless otherwise specified by local codes or manufacturer's guidelines.

35. Vertical runs of backbone cables entering each TR shall be securely fastened along a properly prepared wall in the TR on each floor. Use of cable ladder is recommended.

C. Communications Infrastructure

1. Maximum cable lengths to be 295 feet (90 m) including service loop. Provide all necessary installation materials, tools and equipment

2. Support and secure cables at patch panels using rear cable management bracket, spools or management devise.

3. Cross-connects shall be completed as per construction schedule.

D. Optical Fiber Cable:

1. Inner-ducts of the proper rating will be run between each closeT.

2. Cables for direct burial, aerial, or other outside applications shall be designed specifically for the intended purpose.

3. All optical fiber installations shall be installed using open cabling methods. Limit cable-bending radius to 20 times the cable diameter during installation, and 10 times the diameter after installation. Provide all required tools, materials, consumables, and equipment necessary for field mounting of LC connectors.

4. Do not exceed the maximum pull tension specified by the cable manufacturer. Use appropriate lubricants as required to reduce pulling friction. Avoid kinking and twisting of cables during installation.

5. Label each end of each cable as to source and destination. Terminate optical fibers in consistent, consecutive manner at each end. Place all material in inner-duct between Label Optical Fiber raceway cable with yellow "Caution - Optical Fiber Cable" tags every 10 feet. Leave 10 feet of slack at each fiber termination point. Neatly coil slack optical fiber cable on top of rack above optical fiber patch panel enclosure at each rack location.

6. Optical fiber cable terminations shall utilize enclosures and components in quantities consistent with the required fiber counts at each end of each segment.

7. During optical fiber connector termination, visually inspect all terminations with a 200 or 400-power microscope.

8. Follow all of the connector manufacturer’s recommendations.

9. Unacceptable flaws in the terminations will include, but not limited to, scratches, full or partial cracks, bubbles, pits, epoxy residual, dirt, dust, oil, moisture, grinding and sanding debris. The acceptable termination will show a connector tip that is free of all imperfections in 100% of the core and 80% of the cladding. All unacceptable connectors shall be inspected after rework.

10. During installation of optical fiber cable do not allow pulling tension to exceed cable manufacturer’s specification for the cable being installed. Only the strength member of the cable shall be subjected to the pulling tension.

11. Clean all optical fiber connector tips prior to inserting them into matting receptacles or bulkheads. Install all dust covers

12. Using approved methods, pull cable into conduit, or place into raceway or cable tray as specified. A pull cord (nylon; 1/8” minimum) shall be co-installed with all cable installed in any conduit.

13. Where cables are installed in air return plenum, riser rated cable shall be installed in metallic conduit.

14. Backbone and horizontal cables shall be installed and bundled separately in any pathway.

15. Cables above ceilings or below access floors shall be installed in cable tray or open-top cable hangers.

16. Cable slack and service coils shall be stored properly above the ceiling or under the access floor. Pathway fill ratio in conduit, tray, raceway, etc. shall not exceed 40% of pathway cross-sectional area.

17. A service coil of at least 1 meter is recommended within workstation outlets, and at least 2 meters is recommended for telecommunications enclosures. Main

trunk and OSP cables shall also have a large diameter service coil in the specified location. .

18. Recommended maximum spacing of cable supports above the ceiling is 60 in.

19. Backbone cables spanning more than three floors shall be securely attached at the top of the cable run with a wire mesh grip and on alternating floors or as required by local codes.

20. Vertical runs of cable shall be supported to messenger strand, cable ladder, or other approved structure to support the weight of the cable. Do not exceed maximum cable vertical rise limits.

21. Cables that are damaged during installation shall be replaced by the contractor.

E. RACKS AND ENCLOSURES:

1. Freestanding equipment racks and enclosures shall be protected free of all dust, debris and other environmental elements during construction until substantial completion walk-through.

2. Each rack, enclosure shall have a dedicated #6 AWG ground wire to a grounding buss bar or building ground as defined by NEC.

3. Secure racks and enclosures to floor using rack installation kit.

F. CATEGORY 6 JACKS

1. Refer to specific manufacturer's guidelines for termination of jacks and dressing category 6 cables inside wall outlets and surface housings. Due to the larger size of category 6 cable, service coils in outlet boxes and surface housings are not recommended.

2. Terminate jacks according to manufacturer's instructions.

3. All jack will be wired utilizing T568B.

4. To assure 10GBase-T performance, maintain wiring pair twists as close as possible to the point of termination. Also minimize the length of exposed pairs from the jacket to the IDC termination point during installation.

5. The length of wiring pair un-twist in each termination shall be less than 0.5 inches (13 mm).

6. Jacks shall be properly mounted in plates, frames, or housings with dust caps fully installed over IDC contacts.

7. Horizontal cables extending from mounted jacks shall maintain a minimum bend radius of at least 4 times the cable diameter, unless space is restricted. Note: Refer to specific manufacturer's recommendations for restricted cable bend radius.

8. Cable terminations shall minimize tensile or bending strain on IDC contacts after assembly of faceplate or housing to the wall outlet.

G. CATEGORY 6 PATCH PANELS

1. Properly mount patch panels into the designated rack, cabinet, or bracket locations with the #12-24 screws provided.

2. Terminate cables behind the patch panel according to manufacturer's instructions.

3. To assure performance, maintain wiring pair twists as close as possible to the point of termination. Also minimize the length of exposed pairs from the jacket to the ICD termination point during installation.

4. The length of wiring pair un-twist in each termination shall be less than 0.5 inches (13 mm), and shall be kept to a minimum.

5. Each terminated and dressed cable shall be maintained perpendicular to the rear cover using the recommended cable management hardware.

6. Horizontal or backbone cables extending from the rear panel terminations shall maintain a minimum bend radius of at least 4 times the cable diameter.

7. Cable terminations shall have minimal tensile or bending strain on panel IDC contacts in each installed location.

8. Panels shall be properly labeled on the front and back with the cable number and port connections for each port.

H. Harsh Environment Housing and Connectivity

1. Mount connector housing from front of device, but Install Gasket or optional Protective Cap before mounting connector housing into device.

2. Secure connector housing to device using supplied plastic nut. Tighten nut with 6-7 inch/pounds of torque.

3. Ensure that mounting surface is clean and free of debris.

4. Installing the jack into the mounted connector housing.

5. Install the terminated jack into the mounted connector housing by tilting the jack and securing the fixed latch in the connector opening. Rotate the jack, securing the spring latch.

6. Clean and remove any obstructions from the surface that the wall plate assembly will be installed against.

7. Place washers provided with HI Impact series plates onto screws. Align rubber gasket on back side of plate prior to installing to box/wall by placing screws through plate and rubber gasket.

8. Secure the wall plate assembly to box/wall by tightening screws with 5 inch/pounds of torque.

9. Attach patch cords and field term plug assemblies (sold separately) to the mounted connector

I. OPTICAL FIBER CONNECTORS, HORIZONTAL AND BACKBONE

1. Installed fiber connectors shall have proper cable support, routing and strain relief.

2. Installed connectors shall be inspected 100% for polish quality, and contamination.

3. Fusion splices for pigtail connections shall be protected in a suitable enclosure.

J. GROUNDING and BONDING SYSTEMS: Basic Guidelines

1. Telecommunications grounding and bonding system shall be installed in accordance with NEC requirements, and per the guidelines of ANSI J-STD-607-A.

2. The Telecommunications Main Grounding Buss Bar (TMGB) shall be bonded to the building main electrical service ground (Grounding Electrode Conductor or GEC), using approved lugs or exothermic weld methods. Bonding to the GEC or TMGB with sheet metal screws is prohibited.

3. The Telecommunications Bonding Backbone shall be a minimum 6 AWG copper wire conductor. A Telecommunications Grounding Buss Bar (TGB) shall be installed in the TR on each floor, and shall be bonded to the TBB. All metal racks, cabinets, pathway and enclosures shall be bonded to the TGB.

4. Telecommunications equipment shall be grounded according to manufacturer's instructions and in accordance with applicable codes.

5. All metallic pathways, including conduit, raceway ladder or cable trays shall be electrically continuous and shall be bonded to ground on each end.

6. OSP cable entering the building or backbone cables having metal sheaths shall have isolation protection. Isolation protectors shall be bonded to the TMGB.

3.5 LABELING

A. General:

1. **All labels shall be permanent, machine generated labels produced by a labeling machine**. Labels shall be a permanent polyester material clear in color with label lettering black in color. No hand written labels will be accepted.

2. Labeling information will be reviewed at Pre-Install Meeting, and the Owner shall approve the labeling scheme prior to the installation of any cabling.

3. Surfaces shall be cleaned before attaching labels. All labels shall be attached firmly and vertically plumb on equipment, faceplates, patch panels termination blocks, etc.

4. All labeling of cables, equipment, and components shall be included in as-built documentation, floor plan drawings, and schematic deigns.

B. Cabling

1. All structured cables (horizontal and backbone) shall be labeled at both ends within 6" of cable termination point. Where voice backbone cables extend behind termination blocks, cable labels shall be placed at a location on the cable where the labels are visible from the front of the termination blocks.

2. Labels shall have an adhesive backing and shall wrap completely around the circumference of the cable jacket. Label and lettering sizes shall be of appropriate size in regards to cable diameter.

C. Equipment Racks, Termination Hardware, and Faceplates

1. LABELING SCHEME TO BE SPECIFIED BY OWNER.

3.6 TESTING

A. Category 6 Cable Testing

1. Permanent Link Testing shall be completed on all horizontal (station) cables. The Contractor will be responsible to supply a Channel warranty, but CITY OF MADISON is requiring that the contractor supply all manufacturer patch cords per the contract.

2. Category 6 cabling systems shall be tested as an installed horizontal permanent link configuration. Jacks and faceplates shall be assembled complete and

properly mounted into outlet boxes. Panels shall be terminated complete and fully dressed with proper cable management

3. All wiring shall be certified to meet or exceed the specifications as set forth in TIA-568C for Category 6 requirements for permanent link. All test will be performed to 250MHz.

4. Field Testing shall include the following parameters for each pair of each cable installed:

5. Name of the person performing the test.

6. Test equipment manufacturer and model number.

7. Cable I.D. The test sheets will be in numerical order by cable ID.

8. Date of test.

9. Wire map (pin to pin connectivity and polarity check)

10. Length (in feet)

11. Insertion Loss.

12. Near End Crosstalk (NEXT).

13. Power Sum Near End Crosstalk (PSNEXT).

14. Equal-Level Far End Crosstalk (ELFEXT).

15. Power Sum Equal-Level Far End Crosstalk (PSELFEXT).

16. Return Loss.

17. Delay Skew.

18. Attenuation to Crosstalk ratio (ACR).

19. A “PASS” indication shall be obtained for each link, using at minimum a level III tester that complies with TIA/EIA-568-B.2 field test requirements.

20. Record test results for each cable and turn over to the General Contractor Upon completion of the job. Correct malfunctions when detected, and re-test to demonstrate compliance. Note: Test equipment shall be a Type III cable Tester.

B. Optical Fiber Testing:

1. Test procedures shall be as described by the TIA/EIA-568-B: Commercial Building Telecommunications Cabling Standard, Parts 2 and 3 and TIA/EIA-526-14-A-1998 - Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant-OFSTP-14A

2. Preinstallation Testing:

   a Test each conductor of every optical fiber cable on the reel with a light source and a power meter.

   b Obtain the cable manufacturer power meter test results for each real used on the project. Using the attached Optical Fiber Test Form record the readings and the manufacturer’s reel number. Prior to completion of project, turn over the completed optical fiber test form, optical fiber cable reel ID tags and optical fiber cable manufacturer’s test results.

3. Acceptance Testing:

a Each terminated fiber strand in the horizontal or backbone infrastructure shall be tested individually as a permanent link. A fiber permanent link is defined as a length of individual fiber strand with a connector terminated on each end.

b Testing for multimode shall be at 850 and 1300 nanometers. Total link insertion loss (dB) shall be within the specified link loss budget.

c Tier 1 testing for each installed singlemode link shall be performed as an optical power insertion loss measurement, as defined by ANSI/TIA/EIA-526-7. Testing for singlemode shall be at 1310 and 1550 nanometers. Total link insertion loss (dB) shall be within the specified link loss budget.

d Tier 2 testing, if required for each installed singlemode or multimode link, shall be performed as an OTDR measurement, as defined in TIA-TSB-140. We require Tier 2 testing on all fibers installed in the facility for future troubleshooting.

e Multimode optical fiber attenuation shall be tested on all individual fibers of each cable segment using an LED light source and power meter to determine the actual loss. These tests shall be performed at the 850nm and 1300nm windows in both directions. Test set up and performance shall be in accordance with ANSI/TIA/EIA-526-14A, Method B.

f A reference power measurement shall be obtained by connecting one end of test jumper 1 to the light source and the other end to the power meter. After recording the reference power measurement, test jumper 1 shall be disconnected from the power meter without disturbing the light source and attached to the cable plant. The power meter shall be moved to the far end of the cable plant and attached to the cable plant with test jumper 2.

g Readings must not be higher than the “Optimal Attenuation Loss.” The OAL will be calculated using the manufacturer’s factory certified test results, (db/km) converted to the actual installed lengths plus the manufacturer’s best published attenuation losses for the connector and/or splice installed on this project. (0.30+/-0.30 for Connectors and 0.10 for splices). The construction manager shall use the OAL for comparison with the end to end power loss test results prior to acceptance.

h Test Results: Must be completed and turned over to the General Contractor prior to active equipment installation. Specific due dates for optical fiber will be established at pre-install meeting.

END OF SECTION 27 00 05

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SECTION 27 21 33

WIRELESS ACCESS POINTS (WAP)

PART 1 – GENERAL

1.1. SCOPE

A. The work under this section is for the installation of OWNER PROVIDED, CONTRACTOR INSTALLED Wireless Access Points (WAP).

B. The WAPs shall be installed by the contractor providing and installing the Communications Cable and Equipment. All contractor qualifications and certifications for that section shall apply to this section.

1.2. RELATED SPECIFICATIONS

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of WAP's. This includes but is not limited to the following:

1. 01 31 23 Project Management Web Site
2. 01 33 23 Submittals
3. 27 00 05 Communications Cable and Equipment

1.3. SUBMITTALS

A. Contractor licenses and qualifications are required as part of the complete Division 27 submittal package as indicated under Specification 27 00 05.

B. No submittals are required for the owner provided WAP.

C. Submittals are required for installation/hanger equipment, connectors, and any other required equipment/material required for a complete WAP installation.

PART 2 - PRODUCTS

2.1. WIRELESS ACCESS POINT (WAP) DEVICES

A. The City of Madison Information Technology Department (CoM-IT) will be providing the WAP devices for this project.

B. The WAP device being used will be as manufactured by the Cisco, Model 3700E and shall be used for all types of ceiling mounted installations (suspended, gyp board, open truss, etc).

PART 3 - EXECUTION

3.1. OWNER RESPONSIBILITIES

A. The CoM-IT shall be responsible for ordering, making payment (including shipping fees), and configuring all WAP devices in a timely manner to comply with the Contractors schedule.

B. The CoM-IT shall configure and test each WAP to CoM-IT specifications prior to providing them to the contractor for installation.

C. The CoM-IT shall number each WAP and provide the contractor with a location map indicating where each WAP will be installed.

C. The CoM-IT shall test all WAP's after installation to verify configuration and signaling is correct prior to accepting the final installation of the WAP system.

3.2. CONTRACTORS RESPONSIBILITIES

A. The Contractor shall be solely responsible for coordinating with CoM-IT the scheduling and receipt of all WAP devices with their installation schedule.

B. The Contractor shall inspect all WAP devices upon receipt for damage. CoM-IT shall be notified immediately of any damage.

C. The Contractor shall provide all mounting hardware, blocking, and other items required for a complete installation to the manufacturers installation requirements.

D. The Contractor shall install all WAP devices per plans and specifications including cable connections.
E. The Contractor shall be responsible to pick up WAP devices from City IT and delivery to the jobsite.

3.3. FINAL TESTING

A. Contractor shall provide final testing of all WAP devices after installation is complete.
B. In the event any WAP device is not operating properly the contractor shall trouble shoot the installation and work with the CoM-IT to determine if re-configuration of the device will be required.
C. The CoM-IT shall be responsible for reconfiguring WAP's as needed after installation is complete. The contractor shall be responsible for verifying connections, cabling and connectivity of the installation is correct.

3.4. WARRANTY

A. The CoM-IT will be responsible for registering any warranty information associated with the purchase and ownership of all WAP devices.
B. The Contractor shall warrant the installation of the WAP device for one (1) year per the terms of this contract.

END OF SECTION 27 21 33

SECTION 28 13 00

ACCESS CONTROL SYSTEM (KEYSCAN)

PART 1 - GENERAL

1.1. SUMMARY

A. The City of Madison Information Technology Department has been assisting other City agencies with standardizing facilities through the use of access cards, key fobs, and punch pads. All hardware is installed locally at the facility while software controls access to various doors remotely.

B. These specifications describe the materials, equipment, and installation requirements to install an integrated, computerized access control and alarm monitoring system utilized by the City of Madison Information Technology (CoM-IT) Department.

C. The ACS System Contractor shall be responsible for verifying equipment requirements, locations, and coordination with the General Contractor and all other necessary trades as needed for a complete installation.

D. The ACS System Contractor shall be aware that the installation plans and specifications are for two (2) independent buildings on two (2) separate fire alarm systems and shall be wired as such. Refer to the Part 3-Exectuion for additional details.

1.2. RELATED SPECIFICATIONS

A. 01 31 23 Project Management Web Site
B. 01 33 23 Submittals
C. 08 71 00 Door Hardware
D. 14 21 00 Electric Traction Elevator
E. 27 05 00 Basic Communication Systems Requirements

1.3. RELATED DRAWINGS

A. Refer to all Electrical drawings for locations of distribution panels and equipment as it relates to standard line voltage locations.

B. Refer to all Technical drawings for locations of Access Control System (Keyscan) equipment.

C. Refer to the door hardware schedule and Architectural floor plans for information relating to door access locations and specific hardware requirements.

1.4. REFERENCES

A. The system shall comply with the standards, codes and regulations of the following regulatory bodies:

1. Underwriters Laboratories (UL) Std No. 294 – Access Control System Units
2. Canadian Standards Association (CSA) Std C22.2 No. 205-M1983 – Signal Equipment
3. CE Standards
   a. EN 55022 RF Emissions
   b. EN 55024 RF Immunity
   c. EN 60950-1 Equipment Safety
4. FCC Subpart B – RF Emissions
5. Industry Canada ICES 003 Emissions
6. RoHS

1.5. CONTRACTORS QUALIFICATIONS

A. The Contractor installing the ACS system shall:

1. Be a Certified Keyscan Enterprise Partner
2. Utilize installers who are Keyscan Enterprise Certified Technicians
3. Be based within 25 radial miles of the project location
4. Be able to provide 24/7/365 support during the warranty period of this project

5. Be able to respond and repair or replace most components within 4 hours of notification

1.6. SUBMITTALS

A. The Contractor shall provide a complete submittal package in a timely manner to allow sufficient review time prior to ordering the system components required for a complete installation. The contractor shall be solely responsible for any equipment, purchased/ordered/delivered that is not approved of during the submittal review process.

B. The complete submittal package shall include but not be limited to the following:

1. All certifications of the contractor and contractor's installation team. Certifications shall be current from the start of the contract through the end of the warranty period.
2. Cut sheets indicating, shop drawings, performance data, and other such information that will indicate the component being installed matches the component that was specified.
3. Cut sheets and shop drawing of Contractors recommendations for tags and labels.

1.7. WARRANTY

A. The Contractor shall warrant for one year the complete installation of equipment and components associated with this contract and installation. Contractors warranty shall be in the form of a written letter on company letterhead referring to the contract information, dates of installation and acceptance, signed by an authorized representative of the Contractors Company.

1. The Contractors warranty shall include but not be limited to the following:
   a. Transportation to and from the location as often as needed during the warranty period.
   b. All labor and materials necessary to properly and thoroughly trouble shoot the system.
   c. All fees associated with the shipping of any component that needs to be returned or supplied by the manufacturer for repair or replacement.
   d. All labor and materials required to remove, repair, replace, or re-install any component.

B. The Contractor shall also provide all manufacturers warranties/guarantees associated with installed components of the completed installation.

1.8. QUALITY ASURANCE

A. The Contractor shall be responsible for coordinating their Work with other trades and divisions as needed for a complete installation. This shall include pre-installation meetings for locating equipment, conduit, cabling, control devices, and other materials and equipment required by this installation.

B. The General Contractor (GC) shall be responsible for ensuring that all doors requiring controlled access are properly prepared and installed per the contract documents. The GC shall further be responsible for ensuring all project coordination, pre-installation meetings, submittals and other such project management responsibilities are conducted efficiently and according to the project specifications and schedules.

PART 2 - PRODUCTS

2.1. EXISTING SYSTEM PRODUCTS OVERVIEW

A. The City of Madison Information Technology Department (CoM IT) owns and operates a fully licensed copy of the Keyscan Access Control System software.

1. The Keyscan Access Control System (ACS) provides controlled access to secured doors and elevators through the use of electronic door latches, proximity readers, control panels, and a proprietary software program.
2. The Keyscan software allows CoM-IT and the facility the Owner to customize multiple levels of access and system performance through any combination of the following:

a. Calendar and time based lock/unlock controls
b. Group access control for common personnel groups
c. Individual access control for specialized access control
d. Elevator access control for accessing/not accessing various floors
e. Temporarily disable access control for a specified time period
f. Remotely unlock/lock a door
g. Lockdown a facility from one location
h. Provide customizable alert notifications

2.2. NEW EQUIPMENT AND COMPONENTS

A. The Contractor guarantees that all equipment and components shall be furnished new, undamaged, free of defects, and conform to the drawings and specifications of this contract. The contractor is solely responsible for replacing any damaged or defective item.

B. New ACS components on interior and exterior access doors shall be able to be integrated with the Owners existing system.

2.3. DISTRIBUTION SUPPLY PANEL (AC-DS-1)

A. AC-DS-1 brings line voltage into the ACS system with the following performance specifications:
1. Input
a. 115VAC, 60Hz, 1.45A
2. Output
a. Eight (8) PTC protected outputs
b. 16VAC output
c. 16VAC @ 10amp (175 VA) supply current (1.25 amp per device, 2.5 amp max.)
d. Outputs rated @ 2.5 amp
e. Main fuse rated @ 15 amp/32V
f. Surge suppression
3. Miscellaneous electrical information
a. Operating temperature 0º C to 49ºC ambient
b. 81.89 BTU/hr
c. System AC input VA requirement 166.75 AV
4. Miscellaneous required features
a. AC power LED indicators
b. Illuminated master power disconnect circuit breaker with manual reset
5. Agency Approvals
a. UL 294 listed for Access Control System Units
b. CUL listed-CSA Standard C22.2 No 205-M1983 Signal Equipment

B. AC-DS-1 shall be:
1. Altronix, AL168175CB
2. Pre-approved equal

2.4. POWER SUPPLY PANEL (AC-PS-1)

A. The AC-PS-1 brings line voltage from the AC-DS-1, reduces then distributes the voltage to the Access Security Panels (AC-SEC-1) with the following performance specifications:
1. Input
a. 115VAC, 60Hz, 1.9A
b. Power supply input options
i. One (1) common power input for ACM8 and lock power (factory installed)
ii. Two (2) isolated power inputs; one (1) to power the ACM8 and one (1) for lock accessory power, (external power supply is required). Current is determined by the power supply connected, not to exceed a maximum of 10 amp total
c. Eight (8) Access control System trigger inputs with the following options:
i. Eight (8) normally open (NO) inputs

ii. Eight (8) open collector inputs
iii. Any combination of the above

2. Output
   a. 12VDC or 24VDC @ 6 amp supply current
   b. Eight (8) independently controlled outputs with the following options:
      i. Eight (8) Fail-Safe and/or Fail-Secure power outputs
      ii. Eight (8) form “C” 5 amp rated relay outputs
      iii. Any combination of the above
   c. Eight (8) auxiliary power outputs (un-switched)
   d. Output fuses rated @ 3.5 amp
   e. Filtered and electronically regulated outputs (built-in power supply).
3. Miscellaneous electrical information
   a. Operating temperature 0º C to 49ºC ambient
   b. BTU/hr:
      i. 12VDC = 36.85 BTU/hr
      ii. 24VDC = 73.70 BTU/hr
   c. ACM8 board main fuse is rated at 10 amp
4. Battery Backup
   a. Built-in charger for sealed lead acid or gel type batteries
   b. Power supply board maximum charge current 0.7 amp
   c. Automatic switch over to stand-by battery when AC fails
   d. Zero voltage drop when unit switches over to battery backup (AC failure condition)
   e. Battery fail and battery presence supervision (form “C” contact)
5. Miscellaneous required features
   a. Fire Alarm disconnect (latching or non-latching) is individually selectable for any or all of the eight (8) outputs.
   b. Fire Alarm disconnect input options:
      i. Normally open (NO) or normally closed (NC) dry contact input
      ii. Polarity reversal input for FACP signaling circuit
   c. Alarm output relay indicates that FACP input is triggered (form “C” contact rated @ 1 amp 28VDC)
   d. Short circuit and thermal overload protection
   e. AC fail supervision (form “C” contact)
   f. Red LEDs indicate outputs are triggered (relays energized)
   g. Green LED indicates FACP disconnect is triggered
   h. AC input and DC output LED indicators
   i. Enclosure accommodates up to two (2) 12AH batteries
6. Agency Approvals
   a. UL 294 listed for Access Control System Units
   b. CUL listed-CSA Standard C22.2 No 205-M1983 Signal Equipment

B. AC-PS-1 shall be:
   1. Altronix, AL600ULACM
   2. Pre-approved equal

2.4A. READER POWER SUPPLY PANEL (AC-RPS-1)

A. The AC-RPS-1 brings lines voltage into the ACS to provide power to HID Signo readers. The power supply shall have the following performance specifications:
   1. Input
      a. 115VAC, 60Hz, 3.5A
   2. Output
      a. 12VDC or 24VDC selectable output
      b. 6A continuous supply current
      c. Filtered and electronically regulated output.
      d. Short circuit and thermal overload protection.

3. Battery Backup
   a. Built-in charger for sealed lead acid or gel type batteries.
   b. Automatic switch over to stand-by battery when AC fails.
4. Supervision
   a. AC fail supervision (form “C” contacts).
   b. Notification trigger is selectable for 30 seconds (factory set) or 6 hours.
   c. Low battery supervision (form “C” contacts).
   d. Battery presence supervision (form “C” contacts).
5. Visual Indicators
   a. AC input and DC output LED indicators.
6. Temperature
   a. Operating 0 degrees C to 49 degrees C (32 degrees F to 120 degrees F).
   b. Storage -20 degrees C to 70 degrees C (-4 degrees F to 158 degrees F).
   c. Relative Humidity 85% +/- 5%.
   d. BTU/Hr (approx.):
      12VDC: 37 BTU/Hr.
      24VDC: 74 BTU/Hr.
   e. System AC Input VA requirement: 402.5VA.

B. AC-RPS-1 shall be:
   1. Altronix AL600ULX
   2. Pre-approved equal

2.5. SECURITY PANEL (AC-SEC-1)

A. The AC-SEC-1 distributes the reduced voltage and control wiring to/from each door with an access control device.

B. AC-SEC-1 shall be:
   1. Keyscan CA8500 – 8 Reader Access Control Panel

C. The AC-SEC-1 shall be provided, located and mounted by the Contractor.

2.5A. SECURITY PANEL (AC-SEC-2)

A. The AC-SEC-2 distributes the reduced voltage and control wiring to/from each door to an IT telecommunications room.

B. AC-SEC-2 shall be:
   1. Keyscan CA150 – Single Door Access Control Panel

C. The AC-SEC-2 shall be provided, located and mounted by the Contractor.

2.6. ELEVATOR FLOOR ACCESS CONTROL PANEL (EFACP)

A. The EFACP distributes the reduced voltage and control wiring to the elevator equipment for providing access control to specific floors while providing general public access to others.

B. EFACP shall be:
   1. Keyscan EC1500 – 1 Cab Elevator Floor Access Control Panel

C. The EFACP shall be provided, located and mounted by the Contractor in the elevator machine room (B11).

D. The EFACP requires two (2), 16.5 VAC, 37 or 40VA transformers to be supplied and installed by the Contractor.

2.7. DOOR CONTROL DEVICES

A. The Contractor shall be responsible for verifying the Door Control Device (DCD) quantities and locations with the door hardware schedule.

B. DCD shall be:
   1. HID Global 40KTKS-00-000000– Signo 40 wall mount keypad reader, this reader accepts swipe monitoring of cards, key fobs, and other such devices as well as accepting personal identification numbers (PINs). If a keypad is not needed, the HID Global 40TKS-00-000000 Signo 40 or 20TKS-00-000000 Signo 20 can be used.
      i. Plan designation = AC-CR1-W
   2. The 40KTKS-00-000000, shall be used for all locations including the elevator cab.

2.8. DOOR CONTROL CABLES

A. The following cables are required for a complete installation of the ACS, per controlled door, as follows:
   1. One (1) 22/6 shielded cable, required; to DCD
   2. One (1) 18/2 un-shielded cable, required; lock power
   3. One (1) 22/2 un-shielded cable, required; door contact
   4. One (1) 22/4 un-shielded cable, required but not used; for future request to exit sensors

B. At the Contractors option they may run a manufactured cable bundle containing all four (4) cables listed above. It shall be the sole responsibility of the contractor to appropriately size the conduits for the installation.

PART 3 - EXECUTION

3.1. COOPERATION OF THE ACS CONTRACTOR

A. The Contractor shall be required to coordinate with all trades for a complete and timely installation. This includes attending all pre-installation meetings where equipment locations, conduit locations, and control devices will be installed or may be in conflict with the installation of other trades. The Contractor shall be solely responsible for any additional cost required for removing/replacing/modifying any completed work by other trades because the installation was not properly coordinated.

B. The Contractor shall coordinate with the Owners Representative from City IT for all information necessary to complete the installation and integration with the Owners existing hardware and software.

C. The Contractor shall verify with the appropriate Owners Representative for mounting heights of all hardware and equipment prior to installation. This shall be completed at a pre-installation walk through prior to rough-in.

D. The Contractor shall coordinate with the elevator equipment installer the location and wiring of the EFACP.

E. The Contractor shall coordinate with the Owner's Representative from City IT to verify all requirements for all access controlled doors are properly coordinated and understood prior to roughing in the installation.

3.2. GENERAL EQUIPMENT MOUNTING

A. All ACS equipment shall be mounted to the 3/4" AC fire rated plywood panels provided and installed by the General Contractor. Contractor shall tape out all equipment prior to mounting to insure adequate space is allotted for the complete installation per the riser diagrams including all related conduits and cables.

B. The EFACP shall be mounted to the 3/4" AC fire rated plywood panels provided and installed by the General contractor in the elevator Equipment Room. The General Contractor shall coordinate the location of the plywood panels with the Elevator Equipment Contractor and the ACS Contractor prior to installation.

C. All equipment shall be neatly arranged so as to meet or exceed the manufacturer's recommended working space around each component.

D. Equipment to be installed on plywood mounting panels shall include but not be limited to the following:
   1. Distribution Service Panel (AC-DS-1)
   2. Power Supply Panel (AC-PS-1)
   2a. Reader Power Supply Panel (AC-RPS-1)
   3. Access Control Panel (AC-SEC-1)
   4. Elevator Control Panel (EFACP), including transformers
   5. All required conduits, and boxes for line voltage

3.3. GENERAL CONDUITS AND WIRING

A. This section shall apply to both the ACS Contractor and the Electrical Contractor. The following division of responsibilities shall apply:
   1. The Electrical Contractor shall be responsible for furnishing, installing, and connecting all conduits, connectors, conductors, and other related materials associated with providing line voltage to the ACS system as follows:
      a. Providing an 110V, 15A, dedicated circuit from the designated distribution panel to AC-DS-1 and AC-RPS-1 as described in Section 2.3 above.
      b. Providing line voltage from AC-DS-1 to AC-PS-1 as described in Section 2.4 above.
      c. Providing and installing the required 110V, 20A dedicated duplex outlet in the elevator Equipment Room (B11). Coordinate the location with the ACS Contractor and the Elevator Contractor.
   2. The ACS Contractor shall be responsible for furnishing installing, and connecting all conduits, connectors, conductors and other related materials required to complete the installation of the low voltage wiring and door controller cabling.

B. All conduits shall be properly sized for the number of wires or wire bundles being pulled through the conduit. The Contractor shall verify with the manufacturer the recommended fill rate by conduit size and shall not exceed the recommendations.

C. The contractor shall neatly lay out all conduits in such a fashion so as to minimize bending, crossovers, etc.

D. Bends, pull boxes, and pull points shall be sized and located as per all applicable codes and standards for the number of wires or wire bundles in the bend, pull box, pull point.

E. CAT6 cables from each AC-SEC-1 and the EFACP shall be neatly run in cable management equipment supplied and installed by the cabling contractor or conduits supplied and installed by the ACS Contractor as needed. The switch to be used for all ACS equipment shall be located in Telecom Room 021. Cables shall be labeled on both ends per the cabling specification.

F. The General Contractor and the ACS Contractor shall ensure the following Emergency Access requirements are properly installed and operational prior to the final Madison Fire Department inspection for occupancy.
   1. CoM IT shall provide a minimum of six (6) swipe cards to each installed Knox Box for emergency entrance. The cards shall be appropriately coded for entry at all controlled access doors.
   2. The following doors shall be wired to unlock in the event of an emergency.
      a.

3.4. ACS CONTROL OF ELEVATOR EQUIPMENT

A. The contractor shall coordinate the installation of all required ACS equipment in the elevator Equipment Room with the Elevator Equipment Contractor and the Electrical Contractor.

B. The Elevator Equipment Contractor shall provide and install a 6 conductor, shielded 18 gauge cable between the elevator equipment and the elevator cab for use with the ACS control equipment.

C. The Contractor shall coordinate with the Elevator Equipment Contractor for locating and installing the DCD device (2.7. above) in the elevator cab and for coordinating all wiring between the two systems to attain the desired control specification (3.4.D. below)

D. Prior to programming the elevator controls, coordinate with the City Project Manager and the appropriate representatives from City IT, for final control parameters.

3.5. EQUIPMENT IDENTIFICATION AND LABLEING

A. The Contractor shall provide and install all equipment identification and labeling to the following specifications.
   1. Tags and labels shall be permanent rigid plastic or metal tags with engraved or machine stamped lettering. Hand written self stick or metal hand stamped tags will not be accepted.

2. The Contractor shall work out the labeling scheme for doors with City IT, Owner, and Architect prior to ordering any labels or tags.
3. The Contractor shall provide all labels and tags associated with this specification. This shall include the line voltage feed to each AC-DS-1 from the electrical distribution panel.

B. Panels and Boxes
1. All panels and boxes shall be labeled on the outside cover that readily identifies the panel/box as a "Distribution Supply", "Power Supply", "Access Control Panel", "Elevator Floor Access Control Panel", etc. An associated number shall also be on each tag and the number "1" shall be used even if there is only one of that type panel/box.
2. Access Control Panels shall have a card index inside the front cover of each door indicating the controller number, door number, and door location being served by that panel.

C. Conduits
1. Line voltage from electrical distribution panels shall have conduits labeled on both ends as follows:
   a. At the distribution panel the line voltage conduit shall be labeled with the system supplied, and the ACS distribution supply panel number.
   b. In the Telecommunications Room the line voltage conduit label shall indicate the distribution panel and circuit number(s) controlling the supply line.
2. Conduits between Access Control Panels and the controlled doors shall be labeled on both ends as follows:
   a. In the Telecommunications Room each conduit shall labeled with the door number(s) being supplied.
   b. Above the finished ceiling where the conduit is exposed prior to going into the wall space that serves the door the conduit shall be labeled with the Door Control Panel and Controller number associated with the door being served.
   c. If the conduit size is reduced as control cabling is supplied to doors along the run each change is conduit size shall be re-labeled as noted in 2.b. above.
3. Conduits between equipment and components in the Telecommunications Room do not need to be identified.

3.6. INSTALLATION TESTING AND ACCEPTANCE

A. The CoM IT and the Owner shall be responsible for completing all software programming associated with the installation of this contract prior to the completion of the installation of the system components. It is the sole responsibility of the Contractor to notify the Owner no less than two (2) weeks in advance of completing the installation that all codes and time setting shall be prepared for final installation and testing.

B. The Contractor, CoM IT, and the Owner shall test each access control point with swipe cards and PINs to insure the door unlocks.

C. CoM IT shall test each door using the existing fully integrated software. This shall include but not be limited to the following:
1. Remotely lock/unlock the doors
2. Verify time clock feature works for locking doors
3. Verify swipe cards and PINs work on all doors
4. Verify emergency entrance cards for knox boxes work on all doors for the areas served.

D. The Contractor, CoM IT, and the Owner shall test the elevator floor access functions as follows:
1. With swipe cards and PINs to ensure controlled access to all floors.
2. With no swipe cards or PINs to ensure that the general public can only access the designated public floors and not controlled access floors.
3. Verify time clock feature works for accessing floors

E. A completed and accepted installation shall pass all of the above tests for all controlled access points.

F. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

END OF SECTION 28 13 00

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SECTION 28 20 00

ELECTRONIC SURVEILLANCE

PART 1 – GENERAL

1.1. SUMMARY

A. The City of Madison requires video surveillance of interior and exterior areas of the Lake Street Parking Garage as indicated in the Technology plan sheets.

B. This specification shall identify major equipment components and accessories required for a complete video surveillance installation. It does not include materials such as cables, boxes, connectors, conduit, supports and other ancillary equipment required to complete the installation.

C. For the purposes of this specification the term Contractor shall refer to the person(s) responsible for installing the Electronic Surveillance System and may or may not be the same contractor installing other Division 27 and 28 related equipment. Other contractors having related work shall be referred to by full title (Electrical Contractor).

1.2. RELATED SPECIFICATIONS

A. 01 31 23 Project Management Web Site
B. 01 33 23 Submittals
C. 01 78 23 Operation and Maintenance Data
D. 01 78 36 Warranties
E. 01 78 39 As-Built drawings
F. All Division 27 specifications that may apply to this installation

1.3. AREAS OF RESPONSIBILITY

A. The General Contractor (GC) shall be responsible for ensuring all of the following:
   1. Coordinate all Contractor related work with the construction schedule.
   2. Coordinate all required Work with the Contractor and other trades during pre-installation meetings and resolve installation issues as needed.

B. The Contractor shall be responsible for all of the following:
   1. For all equipment ordering and purchasing, setup, configuration, and testing of equipment being installed under this specification and connected to City of Madison-Information Technology (CoM-IT) servers and equipment.
      a. Include any mounting brackets required for mounting camera equipment to the structure.
      b. The Contractor shall be responsible for the bridge supports identified in Section 2.2.C below.
   2. Verification of Owner installation requirements prior to installing equipment and accessories.
   3. Provide all ancillary materials and equipment required to complete the installation.

C. CoM-IT shall be responsible for all of the following:
   1. The CoM-IT shall be responsible for the ExacQ system licenses.
   2. Provide connection to servers and other hardware necessary to bring installed equipment on line.
   3. Assist in final testing of equipment and equipment functions installed under this specification.

1.4. SUBMITTALS

A. The Contractor shall provide submittals of the following:
   1. All applicable certifications and licenses of the Contractor and the Contractor's installation team. Applicable certifications and licenses shall be current from the start of the contract through the end of the warranty period.
   2. One (1) submittal for <u>all</u> ancillary A/V and A/V Contractor provided equipment required for a complete A/V installation as follows:

a. Product information sheets and shop drawings indicating each type/size/model of A/V accessory required for a complete A/V installation. Information sheets shall include the following information:
   i. Performance data for the item
   ii. Plan identification number(s) where applicable
   iii. Quantity required for each model

1.4. WARRANTY

A. The Contractor shall warrant for one year the complete installation of equipment and components associated with this contract and installation. Contractors warranty shall be in the form of a written letter on company letterhead referring to the contract information, dates of installation and acceptance, signed by an authorized representative of the Contractors Company.
   1. The Contractors warranty shall include but not be limited to the following:
      a. Transportation to and from the location as often as needed during the warranty period.
      b. All labor and materials necessary to properly and thoroughly trouble shoot the system.
      c. All fees associated with the shipping of any component that needs to be returned or supplied by the manufacturer for repair or replacement.
      d. All labor and materials required to remove, repair, replace, or re-install of any component.

B. The Contractor shall also provide all manufacturers warranties/guarantees associated with installed components of the completed installation.

PART 2 - PRODUCTS

2.1. EXTERIOR SURVEILLANCE LOCATIONS

A. The exterior camera shall be a high quality outdoor ready PTZ (pan/tilt/zoom) camera as follows:
   1. AXIS Communications, PTZ Dome Network Camera with the minimum requirements listed below:
      a. HDTV minimum 1920 x 1080p
      b. Certified compatible with Exacq Technologies exacqVision Video Management System
      c. 3 year AXIS extended warranty option

B. Exterior camera mounting accessories shall of high quality and rated for outdoor environments.
   1. AXIS Communications, models as required for the installation of the above noted camera and locations as indicated in the plans and specifications, any substitutions in camera placement to be reviewed and approved by City of Madison Department of Information Technology, with all standard features including the following:
      a. 3 year AXIS extended warranty option

2.2. INTERIOR SURVEILLANCE LOCATIONS

A. The interior camera shall be a high quality indoor ready PTZ (pan/tilt/zoom) camera as follows:
   1. AXIS Communications, PTZ Dome Network Camera with the minimum requirements listed below:
      a. HDTV minimum 1920 x 1080p
      b. Certified compatible with Exacq Technologies exacqVision Video Management System
      c. 3 year AXIS extended warranty option

B. Interior camera mounting accessories shall of high quality and rated for indoor environments,
   1. AXIS Communications, models as required for the installation of the above noted camera and locations as indicated in the plans and specifications, any substitutions in

camera placement to be reviewed and approved by City of Madison Department of Information Technology, with all standard features including the following:
   a. 3 year AXIS extended warranty option
   b. Surface mount as per plans
   c. Drop ceiling mount as per plans

C. All drop ceiling mount locations shall include tile bridge supports
   1. ERICO, SCMKC Security Camera Mounting Kit
   2. Pre-approved equal

PART 3 - EXECUTION

3.1. COOPERATION OF THE CONTRACTOR

A. All line voltage installations that may be required under this specification shall be installed by the Electrical Contractor. Power shall come from the nearest power panel where the equipment is being installed. Label boxes with panel and circuit number for future reference. Installation shall include any fire stopping as required by code.

B. Data cables shall be installed by the Cabling Contractor as required for this installation. Data cables shall come from the nearest Telecom Room where the equipment is being installed. Installation shall include any fire stopping as required by code.

C. The Contractor shall install all security cameras, mounting hardware, boxes and other equipment necessary for a complete installation of the surveillance system.

3.2. EXTERIOR INSTALLATIONS

A. Provide and install all camera mounting hardware, fastening hardware and anchors as needed for a strong, secure and stable installation as necessary for the building materials being mounted to.

B. Provide and install a high grade clear silicone sealant around all mounting hardware.

C. Provide sufficient cable and install a drip loop if cable is exposed outside of the mounting hardware.

D. Label camera end of data cable with permanent data tag indicating switch location connection id.

E. Label switch end of data cable with permanent data tag indicating camera location.

3.3. INTERIOR INSTALLATIONS

A. Provide and install all camera mounting hardware, fastening hardware and anchors as needed for a strong, secure and stable installation as necessary for the building materials being mounted to.

B. Install tile bridge supports at all drop ceiling locations.

C. Label camera end of data cable with permanent data tag indicating switch location connection id.

D. Label switch end of data cable with permanent data tag indicating camera location.

3.4. INSTALLATION TESTING AND ACCEPTANCE

A. Any required system programming (by CoM-IT or Contractor) shall be completed prior to doing any installation testing and acceptance.

B. It is the sole responsibility of the Contractor to notify CoM-IT no less than two (2) weeks in advance of completing the installation to coordinate all final testing of the completed system.

C. The Contractor and CoM-IT shall test each surveillance camera installation to ensure the installed components work per the specifications.
   1. All installed components shall be inspected as follows:
      a. All connections are tight, exterior installations are weather proof with clear silicone sealant.
      b. All components are clean and free of dust, finger prints and other general dirt.
      c. Camera lenses and domes are clean and free of lint, dust and finger prints.
      d. Cameras are free to rotate.
      e. All network connectivity is complete and installed properly.

2. Each camera installation at the project site shall be tested from an off site computer to ensure all pan/tilt/zoom features, focus and other functions are fully operational.

E. A completed and accepted installation shall pass all of the above tests for each installed camera location.

F. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

G. Provide Owner/User training based on the Exacq Vision software.

H. Meet with the Owner/User to check camera views and adjust camera views as needed.

END OF SECTION 28 20 00

SECTION 28 46 21

ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Addressable fire-alarm system.
2. Fire-alarm control unit (FACU).
3. Manual fire-alarm boxes.
4. System smoke detectors.
5. Carbon monoxide detectors.
6. Heat detectors.
7. Fire-alarm notification appliances.
8. Firefighters' two-way telephone communication service.
9. Fire-alarm remote annunciators.
10. Fire-alarm addressable interface devices.

B. Related Requirements:

1. Section 08 71 00 "Door Hardware" for magnetic door holders that release in response to fire-alarm outputs.
2. Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" or Section 26 05 23 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.

1.2 DEFINITIONS

A. DACT: Digital alarm communicator transmitter.

B. FACU: Fire-alarm control unit.

C. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.3 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. Delegated Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and

design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

1. Drawings showing location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of device.
2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.4 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 "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
   b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
   c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
   d. Riser diagram.
   e. Device addresses.
   f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
   g. Record copy of site-specific software.
   h. Provide "Inspection and Testing Form" in accordance with "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.
   i. Manufacturer's required maintenance related to system warranty requirements.
   j. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.

6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ADDRESSABLE FIRE-ALARM SYSTEM

A. Description:

1. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn-and-strobe notification for evacuation.

B. Performance Criteria:

1. Regulatory Requirements:
   a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.
2. General Characteristics:
   a. Automatic sensitivity control of certain smoke detectors.
   b. Fire-alarm signal initiation must be by one or more of the following devices and systems:
      1) Manual stations.
      2) Heat detectors.
      3) Smoke detectors.
      4) Carbon monoxide detectors.
      5) Automatic sprinkler system water flow.
      6) Fire-extinguishing system operation.
      7) Fire standpipe system.
      8) Fire pump running.
      9) .
   c. Fire-alarm signal must initiate the following actions:
      1) Continuously operate alarm notification appliances.
      2) Identify alarm and specific initiating device at FACU and remote annunciators.
      3) Unlock electric door locks in designated egress paths.
      4) Release fire and smoke doors held open by magnetic door holders.
      5) Activate voice/alarm communication system.
      6) Record events in system memory.
      7) Indicate device in alarm on graphic annunciator.
      8) .
   d. Supervisory signal initiation must be by one or more of the following devices and actions:
      1) Valve supervisory switch.
      2) Independent fire-detection and -suppression systems.
      3) Fire pump is running.

4) Fire pump has lost power.
5) Power to fire pump has phase reversal.
6) Zones or individual devices have been disabled.
7) FACU has lost communication with network.
8) .

e. System trouble signal initiation must 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 addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4) Loss of primary power at FACU.
5) Ground or single break in internal circuits of FACU.
6) Abnormal ac voltage at FACU.
7) Break in standby battery circuitry.
8) Failure of battery charging.
9) Abnormal position of switch at FACU or annunciator.
10) Voice signal amplifier failure.
11) .

f. System Supervisory Signal Actions:
1) Identify specific device initiating event at FACU and remote annunciators.
2) Transmit system status to building management system.
3) Display system status on graphic annunciator.

g. Document Storage Box:
1) Description: Enclosure to accommodate standard 8-1/2-by-11 inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
3) Color: Red powder-coat epoxy finish.
4) Labeling: Permanently screened with 1 inch high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
5) Security: Locked with 3/4 inch barrel lock. Provide solid 12 inch stainless steel piano hinge.

2.2 FIRE-ALARM CONTROL UNIT (FACU)

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. Bosch Security Systems, Inc.
2. Edwards; Carrier Global Corporation.
3. Gamewell-FCI; Honeywell International, Inc.
4. Notifier; Honeywell International, Inc.
5. Potter Electric Signal Company, LLC.
6. Siemens Industry, Inc., Building Technologies Division.
7. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
8. Or approved equal

B. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

C. Performance Criteria:

1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. General Characteristics:
   a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
   b. Include real-time clock for time annotation of events on event recorder and printer.
   c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
   d. FACU must be listed for connection to central-station signaling system service.
   e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
   f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.
      1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.
   g. Fire-Alarm Annunciator: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
      1) Annunciator and Display: LCD, 80 characters, minimum.
      2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.
   h. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
      1) Pathway Class Designations: NFPA 72, Class B .
      2) Pathway Survivability: Level 1.
      3) Install no more than 50 addressable devices on each signaling-line circuit.
      4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.
   i. Serial Interfaces:
      1) One dedicated RS 485 port for central-station operation using point ID DACT.
      2) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
   j. Notification-Appliance Circuit:
      1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
      2) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or 5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.
      3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.
   k. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.
   l. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as special module that is part of FACU.
   m. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.

1) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
2) Programmable tone and message sequence selection.
3) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of FACU.

n. Status Annunciator: Indicate status of various voice/alarm speaker zones and status of firefighters' two-way telephone communication zones.

o. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.

p. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate printing of list of existing alarm, supervisory, and trouble conditions in system and historical log of events.

q. Primary Power: 24 V(dc) obtained from 120 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and DACT must be powered by 24 V(dc) source.

r. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.

s. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.

t. Batteries: Sealed lead calcium .

D. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.
2. Preaction System Functionality:
   a. Initiate Presignal Alarm: This function must cause audible and visual alarm and indication to be provided at FACU. Activation of initiation device connected as part of preaction system must be annunciated at FACU only, without activation of general evacuation alarm.

2.3 MANUAL FIRE-ALARM BOXES

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. Bosch Security Systems, Inc.
2. Edwards; Carrier Global Corporation.
3. Gamewell-FCI; Honeywell International, Inc.
4. Notifier; Honeywell International, Inc.
5. Potter Electric Signal Company, LLC.
6. Siemens Industry, Inc., Building Technologies Division.
7. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
8. Or approved equal

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show

visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
2. Station Reset: Key- or wrench-operated switch.
3. Able to perform at up to 90 percent relative humidity at 90 deg F .
4. Able to be used in indoor areas.

2.4 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:

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. Bosch Security Systems, Inc.
   b. Edwards; Carrier Global Corporation.
   c. Gamewell-FCI; Honeywell International, Inc.
   d. Notifier; Honeywell International, Inc.
   e. Potter Electric Signal Company, LLC.
   f. Siemens Industry, Inc., Building Technologies Division.
   g. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
   h. Or approved equal
2. Performance Criteria:
   a. Regulatory Requirements:
      1) NFPA 72.
      2) UL 268.
   b. General Characteristics:
      1) Detectors must be two-wire type.
      2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
      4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
      5) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
      6) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
      7) Operator at FACU, having designated access level, must 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.).
      8) Detector must have functional humidity range within 10 to 90 percent relative humidity.
      9) Sensitivity levels based on time of day.

2.5 CARBON MONOXIDE DETECTORS

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. Notifier; Honeywell International, Inc.
2. Or approved equal

B. Description: Carbon monoxide detector listed for connection to fire-alarm system.

C. Performance Criteria:

1. Regulatory Requirements:
   a. NFPA 72
   b. NFPA 720.
   c. UL 2075.
2. General Characteristics:
   a. Mounting: Adapter plate for outlet box mounting.
   b. Testable by introducing test carbon monoxide into sensing cell.
   c. Detector must provide alarm contacts and trouble contacts.
   d. Detector must send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
   e. Locate, mount, and wire in accordance with manufacturer's written instructions.
   f. Provide means for addressable connection to fire-alarm system.
   g. Test button simulates alarm condition.

2.6 HEAT DETECTORS

A. Combination-Type Heat Detectors:

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. Bosch Security Systems, Inc.
   b. Edwards; Carrier Global Corporation.
   c. Gamewell-FCI; Honeywell International, Inc.
   d. Potter Electric Signal Company, LLC.
   e. Siemens Industry, Inc., Building Technologies Division.
   f. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
   g. Or approved equal
2. Performance Criteria:
   a. Regulatory Requirements:
      1) NFPA 72.
      2) UL 521.
   b. General Characteristics:
      1) Temperature sensors must test for and communicate sensitivity range of device.
   c. Actuated by fixed temperature of 135 deg F or rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
   d. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   e. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
   f. Detector must have functional humidity range of 10 to 90 percent relative humidity.

B. Fixed-Temperature-Type Heat Detectors:

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. Bosch Security Systems, Inc.
   b. Edwards; Carrier Global Corporation.
   c. Gamewell-FCI; Honeywell International, Inc.
   d. Notifier; Honeywell International, Inc.
   e. Potter Electric Signal Company, LLC.
   f. Siemens Industry, Inc., Building Technologies Division.
   g. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
   h. Or approved equal
2. Performance Criteria:
   a. Regulatory Requirements:
      1) NFPA 72.
      2) UL 521.
   b. General Characteristics:
      1) Actuated by temperature that exceeds fixed temperature of 190 deg F .
      2) Mounting: Twist-lock base interchangeable with smoke-detector bases.
      3) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      4) Detector must have functional humidity range of 10 to 90 percent.

2.7 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Audible Notification Appliances:

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. Edwards; Carrier Global Corporation.
   b. Notifier; Honeywell International, Inc.
   c. Potter Electric Signal Company, LLC.
   d. Siemens Industry, Inc., Building Technologies Division.
   e. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
   f. Or approved equal
2. Description: Horns, bells, or other notification devices that cannot output voice messages.
3. Performance Criteria:
   a. Regulatory Requirements:
      1) NFPA 72.
   b. General Characteristics:
      1) Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
      2) Chimes, Low-Level Output: Vibrating type, 75 dB(A-weighted) minimum rated output.
      3) Chimes, High-Level Output: Vibrating type, 81 dB(A-weighted) minimum rated output.
      4) Sounders, High Volume 24 V(dc): Less than 6 mA of alarm current.
      5) Sounders, Low Volume 24 V(dc): Less than 4 mA of alarm current.
      6) Audible notification appliances must have functional humidity range of 10 to 95 percent relative humidity.

7) ISO Temporal 3 Evacuation Tone: 90 plus or minus 4 dB(A-weighted) at 24 V.
8) ISO Temporal 3 Alert Tone: 95 plus or minus 5 dB(A-weighted) at 24 V.
9) AS2220 Evacuation Tone: 93 plus or minus 4 dB(A-weighted) at 24 V.
10) AS2220 Alert Tone: 93 plus or minus 5 dB(A-weighted) at 24 V.
11) Horns: Electric-vibrating-polarized type, 24 V(dc); with provision for housing operating mechanism behind grille. Comply with UL 464. Horns must produce sound-pressure level of 90 dB(A-weighted), measured 10 ft. from horn, using coded signal prescribed in UL 464 test protocol.
12) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Fire-Alarm Visible Notification Appliances:

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. Edwards; Carrier Global Corporation.
   b. Notifier; Honeywell International, Inc.
   c. Potter Electric Signal Company, LLC.
   d. Siemens Industry, Inc., Building Technologies Division.
   e. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
   f. Or approved equal
2. Performance Criteria:
   a. Regulatory Requirements:
      1) NFPA 72.
      2) UL 1971.
   b. General Characteristics:
      1) Rated Light Output:
         a) 15/30/75/110 cd, selectable in field.
      2) Clear or nominal white polycarbonate lens mounted on aluminum faceplate.
      3) Mounting: Wall mounted unless otherwise indicated.
      4) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
      5) Flashing must be in temporal pattern, synchronized with other units.
      6) Strobe Leads: Factory connected to screw terminals.
      7) Mounting Faceplate: Factory finished, red .

2.8 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

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

1. Gamewell-FCI; Honeywell International, Inc.
2. Notifier; Honeywell International, Inc.
3. Or approve equal.

B. Description: Dedicated, two-way, supervised, telephone voice communication links between fire command center, and remote firefighters' telephone stations. Supervised telephone lines must be connected to talk circuits by controls in control module.

C. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:
   a. Common-talk type for firefighter use only.
   b. Selective-talk type for use by firefighters and fire wardens.
   c. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously. Indicator lamp must flash if phone is disconnected from talk circuits.
   d. Addressable firefighters' phone modules to monitor and control loop of firefighter phones. Module must be capable of differentiating between normal, off-hook, and trouble conditions.
   e. Audible Pulse and Tone Generator, and High-Intensity Lamp: When remote telephone is taken off hook, it causes audible signal to sound and high-intensity lamp to flash at fire command center.
   f. Selector panel controls to provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on panel front by individual LEDs.
   g. Display: Digital to indicate location of caller.
   h. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated; factory-standard red finish; with handset.
      1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating Emergency Phone."
      2) With "break-glass" door access lock.
   i. Remote Telephone Jack Stations: Single-gang, stainless steel-plate mounted plug, engraved Fire Emergency Phone.

2.9 FIRE-ALARM REMOTE ANNUNCIATORS

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. Bosch Security Systems, Inc.
2. Or approved equal

B. Performance Criteria:

1. Regulatory Requirements:
   a. NFPA 72.
2. General Characteristics:
   a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, 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 must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

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

1. Bosch Security Systems, Inc.
2. Notifier; Honeywell International, Inc.
3. Or approved equal

B. Performance Criteria:

1. Regulatory Requirements:
   a. NFPA 72.
2. General Characteristics:
   a. Include address-setting means on module.
   b. Store internal identifying code for control panel use to identify module type.
   c. Listed for controlling HVAC fan motor controllers.
   d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
   e. Integral Relay: Capable of providing direct signal to elevator controller to initiate elevator recall .
      1) Allow control panel to switch relay contacts on command.
      2) Have minimum of two normally open and two normally closed contacts available for field wiring.
   f. Control Module:
      1) Operate notification devices.
      2) Operate solenoids for use in sprinkler service.

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 PREPARATION

A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.

B. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install 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 other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inch above finished floor.

C. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in normal path of egress within 60 inch of exit doorway.
2. Mount manual fire-alarm box on background of contrasting color.
3. Operable part of manual fire-alarm box must be between 42 and 48 inch above floor level. Devices must be mounted at same height unless otherwise indicated.

D. Smoke- and Heat-Detector Spacing:

1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing must not exceed 30 ft. .
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inch from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inch from lighting fixture and not directly above pendant mounted or indirect lighting.

E. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend full width of duct. Tubes more than 36 inch long must 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.

G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

H. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

I. Audible Alarm-Indicating Devices: Install not less than 6 inch below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inch below ceiling. Install devices at same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near device they monitor.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 26 05 23 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 PATHWAYS

A. Pathways above recessed ceilings and in inaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inch above floor must be installed in EMT.

B. Exposed EMT must be painted red enamel.

3.7 CONNECTIONS

A. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than 36 inch from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC duct systems.
4. Alarm-initiating connection to elevator recall system and components.
5. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
6. Supervisory connections at elevator shunt-trip breaker.
7. Data communication circuits for connection to building management system.
8. Supervisory connections at fire-extinguisher locations.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 27 05 53 "Identification for Communications Systems."

B. Install framed instructions in location visible from FACU.

3.9 GROUNDING

A. Ground FACU and associated circuits in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction .

B. Administrant for Tests and Inspections:

1. Administer and perform tests and inspections.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
   a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
   b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.
2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify 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.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Provide video recording of training to Owner.

3.12 MAINTENANCE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective

components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.

END OF SECTION 28 46 21.11