EXHIBIT 'D'

SPECIFICATIONS - BID DOCUMENTS

CITY OF MADISON
NAKOOSA TRAIL FLEET/FIRE/RADIO SHOP FACILITY

4151 Nakoosa Trail
Madison, Wisconsin 53714

Volume 1 of 4: Divisions 00 - 01
Volume 2 of 4: Divisions 02 - 14
Volume 3 of 4: Divisions 21 - 30
Volume 4 of 4: Divisions 31 - 45

Contract No. 7528
Munis No. 10305

Prepared by:

Stantec

1600 Wilson Boulevard, Ste. 360
Arlington, VA 22209
Project No.: 376603

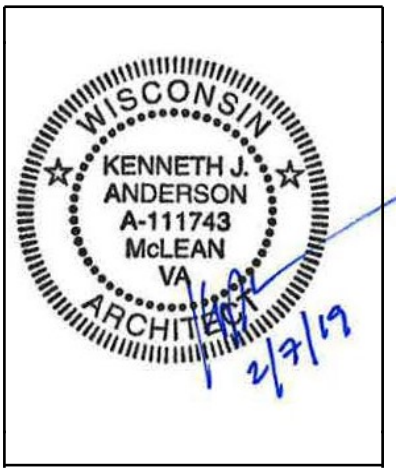
SECTION 00 01 07

SEALS PAGE

DESIGN PROFESSIONALS OF RECORD

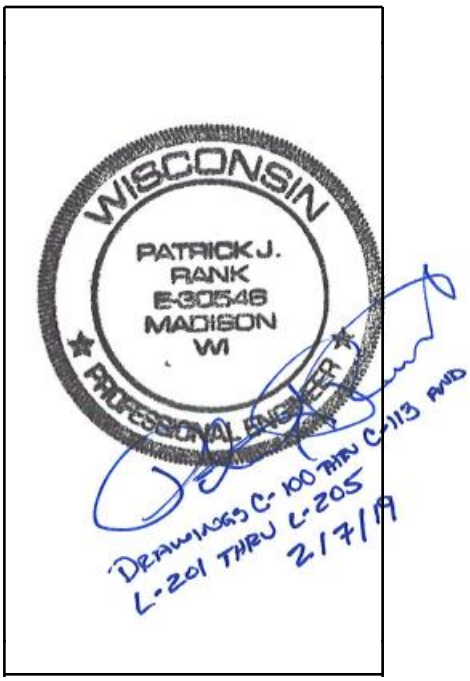
Architect: Stantec Architecture, Inc. [SAI]

Responsible for Divisions 01-49 Sections except where indicated as prepared by other design professionals of record.



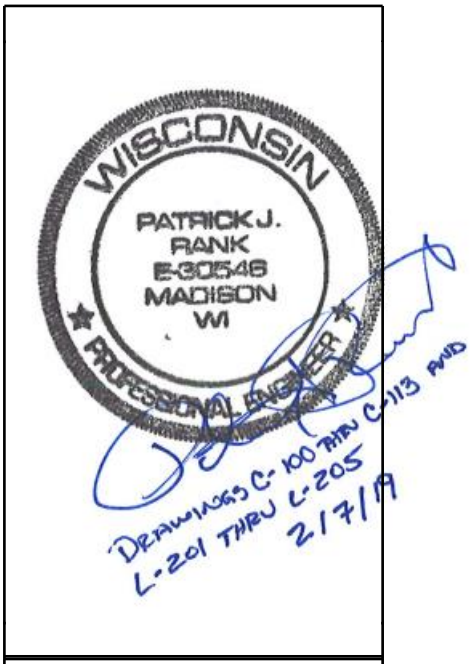
Civil Engineer: Strand Associates [SA]

Responsible for those Sections appended with "[SA]" on Table of Contents.



Landscape Architect: Strand Associates [SA]

Responsible for those Sections appended with "[SA]" on Table of Contents.

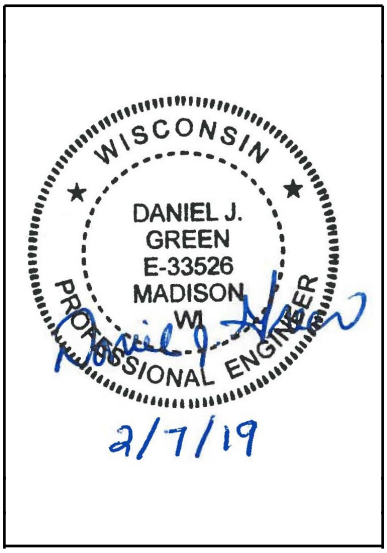


Structural Engineer: Mead & Hunt [M&H]

Responsible for those Sections appended with "[M&H]" on Table of Contents.

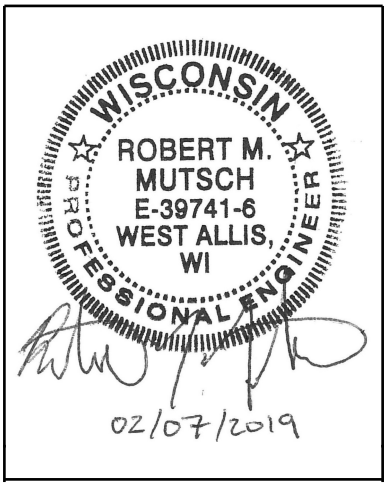
Fire-Protection Engineer: Mead & Hunt [M&H]

Responsible for those Sections appended with "[M&H]" on Table of Contents.



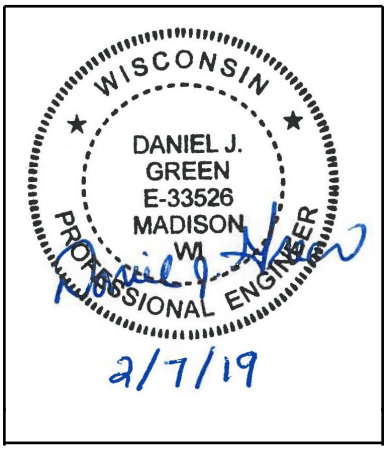
Plumbing Engineer: Mead & Hunt [M&H]

Responsible for those Sections appended with "[M&H]" on Table of Contents.



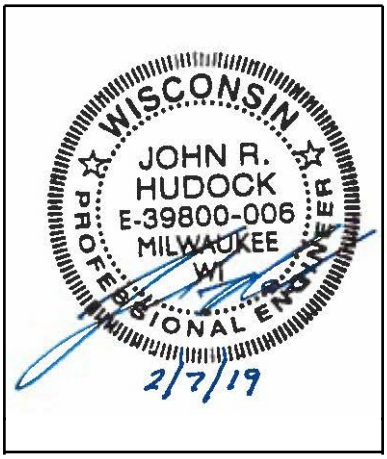
HVAC Engineer: Mead & Hunt [M&H]

Responsible for those Sections appended with "[M&H]" on Table of Contents.



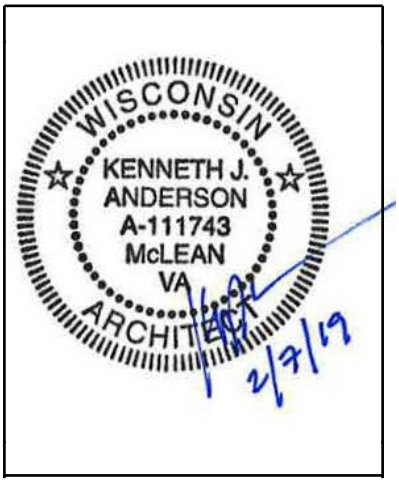
Electrical Engineer: Mead & Hunt [M&H]

Responsible for those Sections appended with "[M&H]" on Table of Contents.



Vehicle Maintenance Equipment Engineer: HDR | MDG [HDR]

Responsible for those Sections appended with "[HDR]" on Table of Contents.



END OF SECTION 00 01 07

SECTION 00 01 09

PROJECT DIRECTORY

1.1 PROJECT TEAM

A. Owner:

1. City of Madison [COM].
2. Department of Public Works.
3. 210 Martin Luther King Jr. Blvd.
4. Madison, WI 53703.
5. Primary Contact(s):
   a. Jim Whitney, JWhitney@cityofmadison.com.
6. Phone: 608-266-4563.
7. City Construction Manager:
   a. Dave Schaller
   b. Phone: 608-243-5891
   c. dschaller@cityofmadison.com
8. Website: www.cityofmadison.com .

B. Architect:

1. Stantec Architecture, Inc. [SAI]
2. 1600 Wilson Blvd., Ste. 360.
3. Arlington, VA 22209.
4. Primary Contact(s):
   a. Maybell Laluna, maybell.laluna@Stantec.com .
   b. Ken Anderson, AIA, ken.j.anderson@stantec.com
5. Phone: 571-290-7679.
6. Website: www.stantec.com .

C. Civil Engineer:

1. Strand Associates [SA].
2. 910 West Wingra Drive.
3. Madison, WI 53715.
4. Primary Contact(s):
   a. Pat Rank, patrick.rank@strand.com .
5. Phone: 608-251-4843.
6. Website: www.strand.com .

D. Stormwater Engineer:

1. Strand Associates [SA].
2. 910 West Wingra Drive.
3. Madison, WI 53715.
4. Primary Contact(s):
   a. John Lindert, Jon.Lindert@strand.com .
5. Phone: 608-251-4843.
6. Website: www.strand.com .
7.
8.

E. Landscape Architect:

1. Strand Associates [SA].
2. 910 West Wingra Drive.

3. Madison, WI 53715.
4. Primary Contact(s):
    a. Rad Hawkos, rad.hawkos@strand.com .
5. Phone: 608-251-4843.
6. Website: www.strand.com .

F. Structural Engineer:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.
4. Primary Contact(s):
    a. David Cockrum, David.Cockrum@meadhunt.com .
5. Phone: 608-273-6380.
6. Website: www.meadhunt.com.

G. Fire-Protection Engineer:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.
4. Primary Contact(s):
    a. Jon Tiede, jon.tiede@meadhunt.com .
5. Phone: 608-443-0569.
6. Website: www.meadhunt.com.

H. Plumbing Engineer:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.
4. Primary Contact(s):
    a. Jon Tiede, jon.tiede@meadhunt.com .
5. Phone: 608-443-0569.
6. Website: www.meadhunt.com.

I. HVAC Engineer:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.
4. Primary Contact(s):
    a. Dan Green, Dan.Green@meadhunt.com .
5. Phone: 608-443-0536.
6. Website: www.meadhunt.com.

J. Electrical Engineer:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.
4. Primary Contact(s):
    a. Jason McCann, jason.mccann@meadhunt.com .
5. Phone: 608-273-6380.
6. Website: www.meadhunt.com.

K. Communications and Audio/Visual Consultant:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.

4. Primary Contact(s):
    a. Jason McCann, jason.mccann@meadhunt.com .
5. Phone: 608-273-6380.
6. Website: www.meadhunt.com.

L. Electronic Safety and Security Consultant:

1. Mead & Hunt [M&H].
2. 2440 Deming Way.
3. Middleton, WI 53562.
4. Primary Contact(s):
    a. John Hudock, John.Hudock@meadhunt.com .
5. Phone: 608-273-6380.
6. Website: www.meadhunt.com.

M. Vehicle Maintenance Equipment Consultant:

1. HDR | MDG [HDR].
2. 70 Xenia Avenue S, Ste. 600.
3. Minneapolis, MN 55416.
4. Primary Contacts:
    a. Jared Weismantel, Jared.Weismantel@hdrinc.com .
5. Phone: 626-389-2444.
6. Website: www.hdrinc.com .

N. Geotechnical Consultant:

1. Construction - Geotechnical Consultants, Inc. (CGC) [CGC].
2. 2921 Perry Street.
3. Madison, WI 53713.
4. Primary Contact(s):
    a. David Staab, dstaab@cgcinc.net.
5. Phone: 608-288-4100.

END OF SECTION 00 01 09

SECTION 00 01 10

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Volume 1 of 4 - Divisions 00 - 01

DIVISION 41 – MATERIAL PROCESSING AND HANDLING EQUIPMENT

END OF SECTION 00 01 10

SECTION 21 90 00

WATER BASED FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Fire suppression system piping designed to operate at working pressure of 175 psig (1200 kPa) maximum.

B. Fire Protection Engineer (FPE): For the purposes of these specifications, the FPE shall have one of the following qualifications:

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

C. NFPA: National Fire Protection Association

1.3 SYSTEM DESCRIPTIONS

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

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

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

a. Date: 2008
b. Static Pressure: 91 psi
c. Measured Flow: 3690 gpm
d. Residual Pressure: 46 psi

2. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
3. Specific sprinkler design parameters shall be per drawings and per NFPA 13 and per FM Global Property Loss Prevention Data Sheets.
4. Maximum Protection Area per Sprinkler: Per UL listing.
5. Contractor shall run a current test to verify pressures and flows.

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

1.5 SUBMITTALS

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

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

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

D. Design documents shall include the features indicated in NFPA 13, which include but are not limited to:

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

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

1. Full name of person who performed the test.
2. Full name of persons who witnessed the test.
3. Date of the test.
4. Static pressure.
5. Flow rate, and corresponding residual pressure when stated flow rate occurred.
6. Sketch indicating site location of hydrants used for test.
7. FPE shall witness or perform the flow test. Flow tests not witnessed or performed by the FPE shall not be used.

F. Qualification Data: For qualified Installer and FPE.

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

1.6 CLOSEOUT SUBMITTALS

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

B. Welding certificates, if field welding was performed.

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

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

E. Record Drawings: Submit drawings showing sprinkler system as installed. Drawings shall include, but are not limited to, all features included in the Delegated-Design Submittal.

1.7 QUALITY ASSURANCE

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

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

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

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

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

1.8 COORDINATION

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

1.9 EXTRA MATERIALS

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

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 STEEL PIPE AND FITTINGS

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

B. Thinwall Black-Steel Pipe: Will not be acceptable.

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

D. Ferrous fittings per NFPA 13.

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

F. Grooved-Joint, Steel-Pipe Appurtenances:

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

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

2. Pressure Rating: 300 psig (2070 kPa) minimum.
3. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

G. Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

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

   a. Victaulic Company.

2.3 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed and FM approved.
2. Minimum Pressure Rating: 175 psig (1200 kPa).

B. Ball Valves:

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

   a. Conbraco Industries, Inc.; Apollo Valves.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.

2. Watts; a Watts Water Technologies company. Description:

   a. Standard: MSS SP-110.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Design: Two piece.
   d. Body Material: Bronze or Ductile Iron.
   e. Stem: Bronze.
   f. Ball: Chrome plated brass.
   g. Port: Full.
   h. Seats: PTFE or TFE.

C. Iron Butterfly Valves:

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

   a. Anvil International.
   b. Milwaukee Valve Company.
   c. NIBCO INC.

d. Tyco Fire & Building Products LP.
e. Victaulic Company.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig (1200 kPa).
4. Body Material: Cast or ductile iron.
5. End Connections: Lug or Grooved.

D. Check Valves:

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

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

2. Standard: UL 312.
3. Pressure Rating: 300 psig (2070 kPa).
4. Type: Swing check.
5. Body Material: Cast iron.
6. End Connections: Flanged or grooved.

E. Bronze OS&Y Gate Valves:

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

a. Milwaukee Valve Company.
b. NIBCO INC.

2. Standard: UL 262.
3. Pressure Rating: 175 psig (1200 kPa).
4. Body Material: Bronze.
5. End Connections: Threaded.

F. Iron OS&Y Gate Valves:

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

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

2. Standard: UL 262.
3. Pressure Rating: 300 psig (2070 kPa).
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

G. Indicating-Type Butterfly Valves:

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

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

2. Standard: UL 1091.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Valves NPS 2 (DN 50) and Smaller:

a. Valve Type: Ball or butterfly.
b. Body Material: Bronze.
c. End Connections: Threaded.

5. Valves NPS 2-1/2 (DN 65) and Larger:

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

6. Valve Operation: Integral supervisory switch.

2.4 SPECIALTY VALVES

A. General Requirements:

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

a. Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.

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

B. Double-Check, Backflow-Prevention Assemblies:

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

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

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

C. Automatic (Ball Drip) Drain Valves:

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

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

2. Standard: UL 1726.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Type: Automatic draining, ball check.

D. Dry-Pipe Valves:

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

a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco Fire & Building Products LP.
c. Victaulic Company.
d. Viking Corporation.

2. Standard: UL 260
3. Design: Differential-pressure type.
4. 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.

E. Riser-Pipe Mounted Air Compressor:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Gast Manufacturing Inc.
b. General Air Products, Inc.
c. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Motor Horsepower: Fractional.
4. Power: 120-V ac, 60 Hz, single phase.

F.

2.5 FIRE-DEPARTMENT CONNECTIONS

A. Exposed-Type, Fire-Department Connection:

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

a. Elkhart Brass Mfg. Co., Inc.
b. Guardian Fire Equipment, Inc.
c. Potter Roemer.
d. Tyco Fire & Building Products LP.

2. Standard: UL 405.
3. Type: Exposed, projecting, for wall mounting.
4. Pressure Rating: 175 psig (1200 kPa) minimum.
5. Body Material: Corrosion-resistant metal.
6. 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.
7. Caps: Brass, lugged type, with gasket and chain.
8. Escutcheon Plate: Round, brass, wall type.
9. Outlet: Back, with pipe threads.
10. Number of Inlets: Two.
11. Escutcheon Plate Marking: Similar to "AUTO SPKR."
12. Finish: Polished brass or bronze.

2.6 SPRINKLER SPECIALTY PIPE FITTINGS

A. Flow Detection and Sprinkler Inspector’s Test Assemblies:

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

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

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

B. Flexible, Sprinkler Hose Fittings:

1. Tyco Fire & Building Products LP.
2. Victaulic Company.
3. Viking Corporation.
4. Standard: UL 1474.
5. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
6. Pressure Rating: 175 psig (1200 kPa) minimum.
7. Size: Same as connected piping, for sprinkler.

C. Fire-rated pipe penetration assembly:

1. Listed for the application.

2.7 SPRINKLERS

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

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

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Characteristics: Quick response, standard coverage, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

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

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

2.8 ALARM DEVICES

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

B. Electrically Operated Alarm Bell:

1. Standard: UL 464.
2. Type: Vibrating, metal alarm bell.
3. Finish: Red-enamel factory finish, suitable for outdoor use.

C. Water-Flow Indicators:

1. Standard: UL 346.
2. Water-Flow Detector: Electrically supervised with tamperproof cover.
3. Type: Paddle operated.
4. Pressure Rating: 250 psig (1725 kPa).
5. Design Installation: Horizontal or vertical.

D. Pressure Switches:

1. Standard: UL 346.
2. Type: Electrically supervised water-flow switch with retard feature.
3. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

1. Standard: UL 346.
2. Type: Electrically supervised.
3. Design: Signals that controlled valve is in other than fully open position.

2.9 PRESSURE GAGES

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

1. Trerice, H. O. Co.
2. Weiss Instruments, Inc.
3. Winters Instruments - U.S.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

D. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum.

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

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

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

3.3 PIPING INSTALLATION

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

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

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

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

D. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) 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.

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

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

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals 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 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

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

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

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

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

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

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

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

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

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

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

3.5 VALVE AND SPECIALTIES INSTALLATION

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

1. Route main drain to exterior. Route auxiliary drains to floor drains or exterior.

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

3.6 SPRINKLER INSTALLATION

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 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire-department connections.

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

3.8 IDENTIFICATION

A. Paint all exterior piping. Apply exterior paint per requirements listed in Division 9.

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

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

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

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

1. Piping flexible connections.
2. Valves.
3. Backflow prevention devices.
4. Inspector’s test fittings.
5. Alarm devices, including electrical devices.
6. Components not listed above but may potentially require servicing.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

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

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

D. Prepare test and inspection reports.

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

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

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

3.11 DEMONSTRATION

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

3.12 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 or grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved 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, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Schedule 40, 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. Schedule 40, 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 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 (DN 65) and larger, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Schedule 40, 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. Schedule 40, 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 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
6. 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.
7. Schedule 10, black-steel pipe with plain ends; welding fittings; and welded joints.

3.13 SPRINKLER SCHEDULE

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

1. Finished spaces: Concealed or recessed pendent sprinklers, factory painted white, with escutcheons.
2. Unfinished spaces: Rough bronze.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright dry sprinklers unless indicated otherwise.

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

C. Use sprinklers with identical temperature ratings throughout compartments.

D. Use sprinklers with identical thermal sensitivities throughout compartments.

END OF SECTION 21 90 00

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SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACCURACY OF DATA AND CONTRACT DRAWINGS

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

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

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

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

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

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

1.3 SUMMARY

A. This Section includes the following:

1. Joining materials
2. Dielectric fittings
3. Escutcheons
4. Sleeves
5. Sealants
6. Through-penetration firestop assembly
7. Wall and floor penetrations

1.4 DEFINITIONS

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

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

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

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings, inside wall spaces, and in chases.

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

F. PVC: Polyvinyl chloride plastic.

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

1.5 SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.

1.6 QUALITY ASSURANCE

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

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

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

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

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

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

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

1.8 COORDINATION

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

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

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.9 CODES AND REGULATIONS

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

1.10 OPERATING AND MAINTENANCE INSTRUCTIONS

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

B. Each separate manual shall consist of the following:

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

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

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

1.11 PROTECTION OF ROOF

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

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

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

1.12 WORK COORDINATION

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

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

1.13 INSPECTION

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

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

PART 2 - PRODUCTS

2.1 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

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

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

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

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

1. Primer: ASTM F 656
2. Cement: ASTM D 2564.
3. Use primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Use cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.2 DIELECTRIC FITTINGS

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

B. Dielectric Unions:

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

a. Jomar
b. Watts
c. Zurn/Wilkins

2. Description:

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

C. Dielectric Flanges:

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

a. Capitol Manufacturing
b. Central Plastics
c. Watts

2. Description:

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

2.3 ESCUTCHEONS

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

2.4 SLEEVES

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

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

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

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

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

2.5 FOUNDATION WALL SLEEVES

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

1. Advance Products & Systems, Inc.
2. Calpico.
3. Link-seal

B. Typical product: Link-seal Model CS

C. Description:

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

2.6 MECHANICAL SLEEVE SEALS

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

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

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

C. Description:

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

2.7 CASING END SEALS

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

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

B. Typical product: Calpico Model W

C. Description:

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

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

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

2.8 SEALANTS

A. Reference Division 7 specification for sealant requirements

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

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

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

C. Install piping in concealed locations. Exceptions:

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

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

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

E. Where piping is installed above accessible ceilings, install piping to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation where required.

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

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

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

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

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

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

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

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

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

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

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

V. Aboveground Non-Fire Barrier Pipe Penetrations

1. All except waterproof floors:

a. Install sleeves for pipes passing through concrete walls, masonry walls, gypsum-board partitions, concrete floors, and roof slabs.
b. Exception: Sleeves are not required for core-drilled holes in concrete.
c. Exception: Permanent sleeves are not required for holes formed in concrete by removable sleeves.

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

2. Waterproof floors:

a. Install sleeves for pipes passing through floors.

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

W. Underground Pipe Penetrations and Transitions

1. Through foundation walls, both sides underground:

a. Install sleeves for pipes passing through foundation walls.
b. Exception: Sleeves are not required for core-drilled holes in concrete.
c. Exception: Permanent sleeves are not required for holes formed in concrete by removable sleeves.

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

2. Through foundation walls, one side underground:

a. Install foundation wall sleeves for pipes passing through foundation walls.
b. Exception: Sleeves are not required for core-drilled holes in concrete.
c. Exception: Permanent sleeves are not required for holes formed in concrete by removable sleeves.

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

X. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

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

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

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

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

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

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

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

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

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

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

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

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

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. In exposed areas, paint plumbing systems, equipment, and components as specified in Division 09 painting Sections.

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

C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

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

3.8 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 22 05 00

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SECTION 22 05 19

METERS AND GAGES FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUBMITTALS

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

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

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ashcroft Inc.
   b. Miljoco Corporation.
   c. Trerice, H. O. Co.
   d. Weiss Instruments, Inc.

B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.

E. Connector Type(s): Union joint, adjustable angle with unified-inch screw threads.

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1.5 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

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

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

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

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.

   a. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
11. Scale Range: 30 deg F - 240 deg F

2.3 THERMOWELLS

A. Thermowells:

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

2.4 PRESSURE GAGES

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

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

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

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel;4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.

10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
12. Scale Range: 0 psi - 200 psi

2.5 GAGE ATTACHMENTS

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

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

H. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.

I. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.

3.2 CONNECTIONS

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

3.3 ADJUSTING

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

END OF SECTION 22 05 19

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SECTION 22 05 23

GENERAL-DUTY VALVES FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Bronze ball valves.
2. Iron, single-flange butterfly valves.
3. Bronze swing check valves.
4. Balancing valves

B. Related Sections:

1. Section 220553 "Identification for Plumbing" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. ASME Compliance:

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set gate valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

1. Handwheel: For valves other than quarter-turn types.
2. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
3. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

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

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.

2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves:

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

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

2. Description:

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

2.3 IRON BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:

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

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

2. Description:

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

2.4 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves:

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

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

2. Description:

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

2.5 BALANCING VALVES

A. Memory-Stop Balancing Valves:

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

a. Conbraco Industries, Inc.
b. Watts.
c. Milwaukee Valve Company.
d. NIBCO INC.

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal or vertical position with hinge pin level.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

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

    a. NPS 2 and Smaller: Bronze swing check.

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

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two-piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 125, bronze disc.
4. Memory Stop Balancing Valves.

B. Pipe NPS 4and Larger:

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

3.6 DRAIN AND VENT VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

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

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

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

END OF SECTION 22 05 23

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

B. Related Sections:

1. Section 220500 “Common Work Results for Plumbing.”

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

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

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

1.5 ACTION SUBMITTALS

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

1.6 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

2.2 TRAPEZE PIPE HANGERS

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

B. Metal Framing System
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.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
6. Coating: Zinc or paint.

2.3 THERMAL-HANGER SHIELD INSERTS

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

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

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

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

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

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

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.5 EQUIPMENT SUPPORTS

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

2.6 MISCELLANEOUS MATERIALS

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

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

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

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

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

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

E. Fastener System Installation:

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

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

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

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

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

and similar units.

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

K. 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.

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

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

N. Insulated Piping:

1. Attach clamps and spacers to piping.

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

2. Install Protective shields that span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

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

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

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

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

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

3.4 ADJUSTING

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

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

3.5 PAINTING

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

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

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

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

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

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

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

L. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

N. 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

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

1.3 ACTION SUBMITTALS

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

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

C. Valve numbering scheme.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Labels for Equipment:

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

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

2. Material and Thickness: Brass, 0.032-inch Multilayer plastic, 1/8 inch minimum thickness and having predrilled or stamped holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Blue.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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

2.2 PIPE LABELS

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

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

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

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

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

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

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

2.3 VALVE TAGS

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

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

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

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

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

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

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."

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

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

D. Pipe Label Color Schedule:

1. Domestic Water Piping

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

2. Sanitary Waste and Storm Drainage Piping:

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

3.5 VALVE-TAG INSTALLATION

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

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

1. Valve-Tag Size and Shape:

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

END OF SECTION 22 05 53

SECTION 22 07 00

INSULATION FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes:

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

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

1.4 QUALITY ASSURANCE

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

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

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

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing."

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

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber, Preformed Pipe Insulation:

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

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

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

G. Mineral-Fiber, Pipe and Tank Insulation:

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

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

2. Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Plenum Insulation for combustible materials

1. Products: Subject to compliance with requirements, provide one of the following:

a. Unifrax FyreWrap
b. 3M Fire Barrier Plenum Wrap

2. High temperature insulation blanket designed to provide a single layer, flexible enclosure around combustible items located within plenums. Comply with ASTM E-136 for non-combustibility, or ASTM E-84 flame spread rating ≤ and a smoke developed rating ≤ 50 as an assembly (insulation material plus combustible material).

2.2 INSULATING CEMENTS

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

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

a. Ramco Insulation, Inc.

2.3 ADHESIVES

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

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

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

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

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

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

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

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

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

2.4 MASTICS

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

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

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

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

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

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

2.5 SEALANTS

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

B. Joint Sealants:

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

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

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

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

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

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

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

2.6 FACTORY-APPLIED JACKETS

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

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

2.7 FIELD-APPLIED JACKETS

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

2.8 TAPES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Compac Corporation.
   b. Ideal Tape Co., Inc., an American Biltrite Company.
   c. Knauf Insulation.
   d. Venture Tape.

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

2.9 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

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

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

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

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

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

1. Draw jacket tight and smooth.

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

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

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

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

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

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

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

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

3.4 PENETRATIONS

A. Insulation Installation at 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: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 7 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 "Penetration Firestopping."

3.5 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.6 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or

union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FINISHES

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

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

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

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

C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

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

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

3.10 PIPING INSULATION SCHEDULE, GENERAL

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

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

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

3.11 EQUIPMENT INSULATION SCHEDULE

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

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

1. Mineral-Fiber Pipe and Tank: 2 inches thick.
2. Mineral-Fiber Preformed Pipe Insulation, Type I: 2 inches thick.

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

1. Flexible Elastomeric: 1 inch thick.
2. Mineral-Fiber Pipe and Tank: 1 inch thick.

D. Domestic hot-water storage tank insulation shall be the following, of thickness to provide an R-value of 12.5:

1. Mineral-fiber pipe and tank.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. Insulation shall be the following:

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

B. Domestic Hot and Recirculated Hot Water:

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

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

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

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

C. Stormwater and Overflow:

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

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

D. Roof Drain and Overflow Drain Bodies:

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

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

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

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

a. Protective shielding pipe covers.

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

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

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

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping and Equipment, Concealed:

1. None.

END OF SECTION 22 07 00

SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.

B. Related Sections:
1. Section 019100 "Commissioning" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. Systems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Complete and deliver construction checklists.

D. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.5 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual Plumbing systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Review equipment and control systems submittals.

D. Witness sample of pressure testing, leak testing, flushing, and equipment startup.

E. Review equipment start-up and checkout plans and forms.

F. Provide test data, inspection reports, and certificates in Systems Manual.

1.6 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:
1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for plumbing systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Test and inspection reports and certificates.
6. Corrective action documents.
7. Verification of testing, adjusting, and balancing reports.

1.7 SUBMITTALS

A. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that plumbing systems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

3.2 TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of testing shall include energy using and related portions of the plumbing system. Testing shall include measuring effectiveness of operational and control functions.

C. The CxA along with the Plumbing Subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.

D. Simulated conditions may need to be imposed on the system. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. The CxA may direct that set points be altered when simulating conditions is not practical. After tests, return settings to normal operating conditions.

E. The following equipment and systems will be tested.
1. Water Heaters.
2. Circulation pumps
3. Balance Valves
4. Flushometers
5. Electric Water Coolers
6. Water Supply Fixtures

END OF SECTION 22 08 00

SECTION 22 11 16

SUPPLY PIPING FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 220500 “Common Work Results for Plumbing.”
2. Section 220519 "Meters and Gages for Plumbing."
3. Section 220529 “Hangers and Supports for Plumbing;”
4. Section 220553 "Identification for Plumbing."
5. Section 221119 Supply Piping Specialties for Plumbing.”

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

2.2 COPPER TUBE AND FITTINGS

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

B. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) water tube, annealed temper.

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

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

E. Copper Unions:

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

F. Copper-Tube, Extruded-Tee Connections:

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

a. T-DRILL Industries Inc.

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

2.3 STAINLESS-STEEL PIPING

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

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

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

2.4 PEX TUBE AND FITTINGS

A. PEX Distribution System: ASTM F 876, ASTM F 877, SDR 9 tubing.

B. Fittings for PEX Tube: ASTM F 1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.

C. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 877; with plastic or corrosion-resistant-metal valve for each outlet.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

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

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

D. Flux: ASTM B 813, water flushable.

2.6 ENCASEMENT FOR PIPING

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

B. Form: Sheet.

C. Color: Black.

2.7 TRANSITION FITTINGS

A. General Requirements:

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

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

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

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

B. Install 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 underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

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

F. Install shutoff valve immediately upstream of each dielectric fitting.

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

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

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

J. 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.

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

L. Install piping to permit valve servicing.

M. 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.

N. Install piping free of sags and bends.

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

P. Install PEX piping under floor without fitting for wall hydrants only.

Q. Install PEX piping with loop at each change of direction of more than 90 degrees.

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

S. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing."

T. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."

U. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in 22 05 00 – “Common Work Results for Plumbing”

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 “Common Work Results for Plumbing."

3.3 JOINT CONSTRUCTION

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

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

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

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

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

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

F. 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.

G. Joints for PEX Piping: Join according to ASTM F 1807.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

3.5 DIELECTRIC FITTING INSTALLATION

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

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing."

3.7 CONNECTIONS

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

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

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

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

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

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

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

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

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

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

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

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

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

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

3.11 CLEANING

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

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

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

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

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

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

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

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

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

3.12 PIPING SCHEDULE

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

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

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

D. Under-building-slab, domestic water piping,, shall be one of the following:

1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and solder joints.

2. PEX tube, NPS 1 and smaller, fittings for PEX tube; and crimped joints.

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

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

3.13 VALVE SCHEDULE

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

1. Shutoff Duty: Use ball valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves for piping NPS 2-1/2 (DN 65) and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves for piping NPS 2-1/2 (DN 65) and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

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

END OF SECTION 22 11 16

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SECTION 22 11 19

SUPPLY PIPING SPECIALTIES FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Temperature-actuated, water mixing valves.
5. Strainers.
6. Outlet boxes.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water-hammer arresters.
11. Air vents.
12. Trap-seal device.
13. Flexible connectors.

B. Related Requirements:

1. Section 220519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

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

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

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

2.2 PERFORMANCE REQUIREMENTS

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

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

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

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

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

B. Hose-Connection Vacuum Breakers:

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

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

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

C. Pressure Vacuum Breakers:

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

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

2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Accessories:

    a. Valves: Ball type, on inlet and outlet.

D. Spill-Resistant Vacuum Breakers:

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

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

2. Standard: ASSE 1056.
3. Operation: Continuous-pressure applications.
4. Accessories:

a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

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

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

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

a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

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

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

2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron or steel with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water-Control Valves:

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

a. CLA-VAL Automatic Control Valves.

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

2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
3. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body with stainless steel trim.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:

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

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

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

B. Individual-Fixture, Water Tempering Valves:

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

a. Lawler Manufacturing Company, Inc.
b. Watts.
c. Powers.

2. Standard: ASSE 1016 or ASSE 1070, thermostatically controlled, water tempering valve.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Finish: Rough or chrome-plated bronze.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

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

5. Drain: Factory-installed, hose-end drain valve.

2.8 OUTLET BOXES

A. Icemaker Outlet Boxes:

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

   a. Acorn Engineering Company.
   b. IPS Corporation.
   c. Oatey.

2. Mounting: Recessed.
3. Material and Finish: Stainless-steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.9 HOSE BIBBS

A. Hose Bibbs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Chicago Faucets
   b. Smith, Jay R. Mfg. Co.
   c. Watts; a Watts Water Technologies company.
   d. Woodford Manufacturing Company.
   e. Zurn Industries, LLC.

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

2.10 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Smith, Jay R. Mfg. Co.
   b. Watts; a Watts Water Technologies company.
   c. Woodford Manufacturing Company.
   d. Zurn Industries, LLC.

2. Standard: ASSE 1019, Type B.
3. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
4. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Pressure Rating: 125 psig.
6. Operation: Loose key.
7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
8. Inlet: NPS 1/2 or NPS 3/4.
9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.11 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.

2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sioux Chief Manufacturing Company, Inc.
   b. Smith, Jay R. Mfg. Co.
   c. Watts; a Watts Water Technologies company.
   d. Zurn Industries, LLC.

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

2.13 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.14 TRAP-SEAL DEVICE

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

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

   a. Sioux Chief Manufacturing Company, Inc.

b. Smith, Jay R. Mfg. Co.
c. Watts; a Watts Water Technologies company.
d. ProVent Systems

2. Standard: ASSE 1072, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.
3. Size: NPS 1-1/4 minimum.
4. Material: Chrome-plated, cast brass.

2.15 FLEXIBLE CONNECTORS

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

1. Flexicraft Industries.
2. Flex-Weld, Inc.
3. Metraflex Company (The).

B. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.1 INSTALLATION

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

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

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

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

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

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

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

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

G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs when using surface mounted style.

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

I. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

J. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

K. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

L. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 LABELING AND IDENTIFYING

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

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
4. Water pressure-reducing valves.
5. Primary, thermostatic, water mixing valves.
6. Individual fixture water tempering valves.
7. Outlet boxes.
8. Supply-type, trap-seal primer device.
9. Electronic style, trap-seal primer device.

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

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

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

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

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable 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.

END OF SECTION 22 11 19

SECTION 22 11 23

SUPPLY PIPING PUMPS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. In-line, seal less centrifugal pumps.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1, without amendments, Section 7 - "Service Water Heating."

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

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

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. Protect bearings and couplings against damage.

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

1.8 COORDINATION

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

PART 2 - PRODUCTS

2.1 IN-LINE, VARIABLE SPEED ECM MOTOR PUMPS

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

1. Bell & Gossett; a Xylem brand.
2. Grundfos Pumps Corp.
3. Wilo USA, LLC.

B. Description: Factory-assembled and –tested, single-stage, in-line, variable speed centrifugal pumps with integral speed control.

C. Pump Construction:

1. Casing: Bronze or Stainless Steel, with companion-flange connections.
2. Impeller: Corrosion-resistant material.
3. Motor: Integrated synchronous motor using ECM technology with permanent magnetic rotor.
4. Control: Pump speed will vary to maintain a constant temperature of the fluid.

2.2 CONTROLS

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

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F (18 to 93 deg C).
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Settings: Start pump at 110 deg F (43 deg C) and stop pump at 120 deg F (49 deg C).

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

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

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

D. Install pumps with motors and pump shafts horizontal.

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

F. Install thermostats in hot-water return piping.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Supply Piping for Plumbing." Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

1. Install shutoff valve and strainer on suction side of each in-line, pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping.

D. Connect thermostats to pumps that they control.

3.4 IDENTIFICATION

A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Perform visual and mechanical inspection.

3.6 STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats, 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; prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.

3.7 ADJUSTING

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

B. Adjust initial temperature set points.

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

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

END OF SECTION 22 11 23

SECTION 22 13 16

DRAIN AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

B. Related Sections:

1. Section 221313 "Facility Sewer Piping" for sanitary sewerage piping and structures outside the building.

1.3 PERFORMANCE REQUIREMENTS

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

1. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).
2. Waste, Force-Main Piping: 100 psig (690 kPa).

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.4 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

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

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

1.7 PROJECT CONDITIONS

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

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

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

B. Gaskets: ASTM C 564, rubber.

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

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

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

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

C. CISPI, Hubless-Piping Couplings:

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

a. ANACO-Husky.
b. Fernco Inc.
c. Mission Rubber Company, LLC; a division of MCP Industries.
d. Tyler Pipe; a subsidiary of McWane Inc.

2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Heavy-Duty, Hubless-Piping Couplings:

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

a. ANACO-Husky.
b. Clamp-All Corp.
c. Mission Rubber Company, LLC; a division of MCP Industries.
d. Tyler Pipe; a subsidiary of McWane Inc.

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

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

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

B. Steel Pipe Pressure Fittings:

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

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

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.5 PVC PIPE AND FITTINGS

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

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

C. Adhesive Primer: ASTM F 656.

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

D. Solvent Cement: ASTM D 2564.

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

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

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

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

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

b. Standard: ASTM C 1173.

c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

d. Sleeve Materials:

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

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

2. Dielectric Unions:

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

1) Watts; a Watts Water Technologies company.
2) Wilkins.
3) Zurn Industries, LLC.

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 150 psig (1035 kPa).
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

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

1) Watts; a Watts Water Technologies company.
2) Wilkins.
3) Zurn Industries, LLC.

b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 150 psig (1035 kPa).
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

a. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig (1035 kPa).
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.
5) Washers: Phenolic with steel backing washers.

5. Dielectric Nipples:

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

1) Grinnell Mechanical Products.
2) Precision Plumbing Products.
3) Victaulic Company.

b. Description:

1) Standard: IAPMO PS 66
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

2.7 ENCASEMENT FOR UNDERGROUND METAL PIPING

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

B. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) minimum thickness.

C. Form: Sheet.

D. Color: Black.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated 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. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

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

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

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

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

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

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

O. Install steel piping according to applicable plumbing code.

P. Install stainless-steel piping according to ASME A112.3.1 and applicable plumbing code.

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

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

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

T. Install engineered soil and waste drainage and vent piping systems as follows:

U. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

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

V. Install force mains at elevations indicated.

W. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping. Comply with requirements for backwater valves specified in Section 221319 "Drain Piping Specialties for Plumbing."
2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 221319 "Drain Piping Specialties for Plumbing."
3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 221319 "Drain Piping Specialties for Plumbing."

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

Y. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."

Z. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."

AA. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

3.3 JOINT CONSTRUCTION

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

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.

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

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

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

E. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

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

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

H. 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 OD's.
2. In Drainage Piping: Unshielded, nonpressure transition couplings.
3. In Force Main Piping: Fitting-type transition couplings.

B. Dielectric Fittings:

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

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 220523 “General-Duty Valves for Plumbing.”

B. Shutoff Valves:

1. Install full-port ball valve for piping NPS 2 (DN 50) and smaller.
2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.

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

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

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Comply with requirements for backwater valve specified in Section 221319 "Drain Piping Specialties for Plumbing."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing."

3.7 CONNECTIONS

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

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

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

5. Install horizontal backwater valves with cleanout cover flush with floor.
6. Comply with requirements for backwater valves cleanouts and drains specified in Section 221319 "Drain Piping Specialties for Plumbing."
7. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

D. Connect force-main piping to the following:

1. Sanitary Sewer: To exterior force main.
2. Sewage Pump: To sewage pump discharge.

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

F. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing."

3.9 FIELD QUALITY CONTROL

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

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

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

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

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

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa).

Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

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

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

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

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

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

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

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

3.11 PIPING SCHEDULE

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

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

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Stainless-steel pipe and fittings, sealing rings, and gasketed joints.
4. Copper DWV tube, copper drainage fittings, and soldered joints.
5. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
6. Solid-wall CPVC pipe, CPVC socket fittings, and solvent-cemented joints.
7. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

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

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

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

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.

2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
4. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

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

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

END OF SECTION 22 13 16

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SECTION 22 13 19

DRAIN PIPING SPECIALTIES FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Backwater valves.
2. Cleanouts.
3. Floor drains.
4. Trench drains.
5. Roof drains.
6. Miscellaneous sanitary drainage piping specialties.
7. Flashing materials.
8. Catch Basins

B. Related Requirements:

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

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

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

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

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

1.7 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company.
    b. Smith, Jay R. Mfg. Co.
    c. Tyler Pipe; a subsidiary of McWane Inc.
    d. Watts; a Watts Water Technologies company.
    e. Zurn Industries, LLC.
2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Combination Flashing Ring and Gravel Stop: As Required.
5. Flow-Control Weirs: Not required.
6. Outlet: Bottom
7. Extension Collars: Required.
8. Underdeck Clamp: Required.
9. Sump Receiver Plate: Required.
10. Dome Material: Aluminum.
11. Perforated Gravel Guard: Stainless steel.
12. Vandal-Proof Dome: Required.
13. Water Dam: Not required 2 inches high.
14. See fixture schedule for model number and type

B. Cast-Iron, Medium-Sump, General-Purpose Roof Drains:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company.
    b. Smith, Jay R. Mfg. Co.
    c. Tyler Pipe; a subsidiary of McWane Inc.
    d. Watts; a Watts Water Technologies company.
    e. Zurn Industries, LLC.
2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Combination Flashing Ring and Gravel Stop: Required.
5. Outlet: Bottom.
6. Underdeck Clamp: Required.
7. Dome Material: Aluminum.
8. Combination roof drain and overflow drain. See fixture schedule.

2.2 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:

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

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

2. Standard: ASME A112.14.1.
3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain-Outlet Backwater Valves:

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

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

2. Size: Same as floor drain outlet.
3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

C. Horizontal, Plastic Backwater Valves:

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

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

2. Size: Same as connected piping.
3. Body: PVC.
4. Cover: Same material as body with threaded access to check valve.
5. Check Valve: Removable swing check.
6. End Connections: Socket type.
7. Extension: Service class; Class 125, schedule 40, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.3 CLEANOUTS

A. Metal Floor Cleanouts:

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

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

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

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

B. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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

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

2.4 FLOOR DRAINS

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

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

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

B. Hub Drains
1. Description:

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

C. Floor Sinks

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

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

2. Body Material: Cast Iron with acid resistant finish.
3. Seepage Flange: Not Required.
4. Clamping Device: Not Required.
5. Outlet: Bottom.
6. Top or Strainer Material: Nickel bronze half grate.
7. Top Loading Classification: Medium Duty.
8. Trap Material: Same as connected drain pipe.
9. Trap Pattern: Deep-seal P-trap.
10. Trap Features: Trap-seal primer valve drain connection.

2.5 LINEAR SLOT DRAINAGE SYSTEMS

A. Stainless-Steel Channel Drainage Systems, ASME A112.3.1:

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

    a. Josam Company.
    b. ZURN.

2. Description: Modular system of stainless-steel channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
3. Standard: ASME A112.3.1 for trench drains.
4. Channel Sections: Interlocking joint, stainless steel with level invert.

    a. Dimensions: 4.5 inches wide. Include number of units required to form total lengths indicated.

5. Grates: Manufacturer's designation "medium duty," with slots or perforations, and of width and thickness that fit recesses in channels.

    a. Material: Stainless steel.
    b. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

6. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Air-Gap Fittings:

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

B. Stack Flashing Fittings:

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

2. Size: Same as connected stack vent or vent stack.

2.7 CATCH BASINS

A. Standard Precast Concrete Catch Basins: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Base Section: 6” minimum thickness for floor slab and 4” minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
2. Riser Sections: 4” minimum thickness, 48” diameter, and lengths to provide depth indicated.
3. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
4. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
5. Grade Rings: Include two (2) or three (3) reinforced-concrete rings, of 6” to 9” total thickness that match 24” diameter frame and grate.
6. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one (1) step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12” to 16” intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60”.
7. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16 (ASSHTO HS20-44), structural loading. Include 24” ID by 7” to 9” riser with 4” minimum width flange, and 26” diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backwater valves in building drain piping where indicated on drawings. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

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

1. Size same as drainage piping up to NPS 4. Use NPS 4DN 100for 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 75 feet40 feet NPS 2 75 feet (23 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

L. 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.

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

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

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

P. Install wood-blocking reinforcement for wall-mounting-type specialties.

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

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Drain and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

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

3.4 PROTECTION

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

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

END OF SECTION 22 13 19

SECTION 22 13 23

DRAIN INTERCEPTORS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Oil interceptors.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of plastic interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.

B. Shop Drawings: For each type and size of precast-concrete interceptor indicated.

1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, based on input from Installers of the items involved:

1. Interceptors.
2. Piping connections. Include size, location, and elevation of each.

3. Interface with underground structures and utility services.

PART 2 - PRODUCTS

2.1 OIL INTERCEPTORS

A. Plastic or Fiberglass Oil Interceptors:

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

a. Green Turtle Zurn.
b. Schier Products Company.
c. Town & Country Plastics, Inc.

2. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain oil and to permit wastewater flow.
3. Structural Design Loads:

a. Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).

4. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch- minimum width flange and 26-inch diameter cover.

a. Include indented top design with lettering cast into cover, using wording equivalent to "OIL INTERCEPTOR."

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 "Earth Moving."

3.2 INSTALLATION

A. Install exterior precast-concrete interceptors according to ASTM C 891. Set level and plumb.

B. Install risers from top of underground exterior interceptors to manholes and gratings at finished grade.

C. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches above finish surface elsewhere, unless otherwise indicated.

D. Set tops of grating frames and grates flush with finished surface.

E. Set plastic interceptors level and plumb.

F. Install interior grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor, unless otherwise indicated.
2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
3. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

G. Install grease removal devices on floor. Install trap, vent, and flow-control fitting according to authorities having jurisdiction. Install control panel adjacent to unit, unless otherwise indicated.

H. Install oil interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 221316 "Drain and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

C. Oil Interceptors: Connect inlet, outlet, vent; flow-control fitting and vent to unit inlet piping.

3.4 IDENTIFICATION

A. Identification materials and installation are specified in Division 31 "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.

1. Use warning tapes or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled grease removal devices and their installation, including piping and electrical connections, and to assist in testing.

END OF SECTION 22 13 23

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SECTION 22 31 00

DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Water softeners.
2. Water-testing sets.

1.3 ACTION SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water softeners.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

1. Signed by manufacturer certifying that water softener complies with requirements.
2. Mineral tank pressure test report. Provide report of pressure tests. Report shall identify each tank by serial number, shall indicate the maximum pressure attained, and shall be signed by the individual that conducted the test.

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

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

B. Maintenance service agreement.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Salt for Brine Tanks: Furnish in same form as and at least four times original load, but not less than 2000 lb (908 kg). Deliver on pallets according to the following:

    a. Plain Pellet Salt: In 40- or 50-lb (18.1- or 22.7-kg) packages.

2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.

1.7 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water softeners and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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

C. ASME Compliance: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code, where indicated.

D. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

1.8 COORDINATION

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

1.9 WARRANTY

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

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

    a. Structural failures of mineral and brine tanks.
    b. Faulty operation of controls.
    c. Deterioration of metals, metal finishes, and other materials beyond normal use.
    d. Attrition loss of resin exceeding 3 percent per year.
    e. Mineral washed out of system during service run or backwashing period.
    f. Effluent turbidity greater and color darker than incoming water.
    g. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.

2. Warranty Period: 5 years from date of Substantial Completion.

1.10 MAINTENANCE SERVICE

A. Maintenance: Submit four copies of manufacturer's "Agreement for Continued Service and Maintenance," before Substantial Completion, for Owner's acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing to include replacing materials and equipment. Include one-year term of agreement with option for one-year renewal.

PART 2 - PRODUCTS

1.11 WATER SOFTENERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hellenbrand Inc.
   2. Capital Water Softener.

B. Refer to Drawing fixture / Equipment schedules for type and model number.

C. Description: Factory-assembled, pressure-type water softener.

   1. Standard: Comply with NSF 61 Annex, "Drinking Water System Components - Health Effects."
   2. Configuration: Twin unit with two mineral tanks and one brine tank.
   3. Mounting: On skids.
   4. Mineral Tanks: Stainless Steel, Steel or FRP, pressure-vessel quality.

      a. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code."
      b. Pressure Rating: 125 psig (860 kPa) minimum.
      c. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
      d. Upper Distribution System: Single-point, diffuser type.
      e. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, non-clogging plastic strainers, and arranged for even flow distribution through resin bed.
      f. Handholes: 4 inches (102 mm) round or 4 by 6 inches (102 by 152 mm) elliptical, in top head and lower sidewall of tanks 30 inches (762 mm) and smaller in diameter.
      g. Liner: PE, ABS, or other material suitable for potable water.

   5. Controls: Electronic programmable, fully automatic; factory wired and factory mounted on unit.

      a. Adjustable duration of various regeneration steps.
      b. Push-button start and complete manual operation.
      c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
      d. Electronic water meter, adjustable to initiate regeneration according to time clock schedule or by volume override.

   6. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressure; does not require field adjustments.

      a. Demand-Initiated Control: Each mineral tank of twin mineral-tank unit is equipped with automatic-reset-head water meter that electrically activates cycle controllers to initiate regeneration at preset total in gallons (liters). Head automatically resets to preset total in gallons (liters) for next service run. Electrical lockout prevents simultaneous regeneration of both tanks.

   7. Brine Tank: Combination measuring and wet-salt storing system.

      a. Tank and Cover Material: Fiberglass, 3/16 inch (4.8 mm) thick; or molded PE, 3/8 inch (9.5 mm) thick.
      b. Brine Valve: Float operated, and plastic fitted for automatic control of brine withdrawal and freshwater refill.
      c. Size: Large enough for at least four regenerations at full salting.

   8. Factory-Installed Accessories:

a. Piping, valves, tubing, and drains.
b. Sampling cocks.
c. Main-operating-valve position indicators.
d. Water meters.

1.12 CHEMICALS

A. Mineral: High-capacity ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.

B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

1.13 WATER-TESTING SETS

A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

1.14 SOURCE QUALITY CONTROL

A. Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

1.15 WATER SOFTENER INSTALLATION

A. Equipment Mounting:

1. Install water softeners on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 33.

B. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.

C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

D. Install water-testing sets mounted on wall, unless otherwise indicated, and near water softeners.

1.16 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Supply Piping for Plumbing." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to equipment, allow space for service and maintenance of equipment.

C. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.

1. Metal and plastic valves are specified in Section 220523 “General-Duty Valves for Plumbing”.
2. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

D. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Section 220519 "Meters and Gages for Plumbing."

1. Exception: Water softeners with factory-installed pressure gages at locations indicated.

E. Install valved bypass in water piping around water softeners.

1. Metal and plastic valves are specified in Section 220523 “General-Duty Valves for Plumbing”. Water piping is specified in Section 221116 "Supply Piping for Plumbing."

F. Install drains as indirect wastes to spill into open drains or over floor drains or floor sinks.

1.17 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing."

1.18 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Water softeners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

1.19 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Add water to brine tanks and fill with salt:

C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:

1. ASTM D 859, "Test Method for Silica in Water."
2. ASTM D 1067, "Test Methods for Acidity or Alkalinity of Water."
3. ASTM D 1068, "Test Methods for Iron in Water."
4. ASTM D 1126, "Test Method for Hardness in Water."
5. ASTM D 1129, "Terminology Relating to Water."
6. ASTM D 3370, "Practices for Sampling Water from Closed Conduits."

1.20 DEMONSTRATION

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

END OF SECTION 22 31 00

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SECTION 22 34 00

FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
2. Domestic-water heater accessories.

1.3 PERFORMANCE REQUIREMENTS

1.4 ACTION SUBMITTALS

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

B. LEED Submittals:

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

C. Shop Drawings:

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

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of domestic-water heater, from manufacturer.

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

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

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

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

C. ASME Compliance:

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

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

1.8 COORDINATION

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

1.9 WARRANTY

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

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

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

2. Warranty Periods: From date of Substantial Completion.

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

1) Storage Tank: Five years.
2) Controls and Other Components: Three year(s).

b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:

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

a. HTP.
b. PVI.
c. Lochnivar.

2. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
3. Storage-Tank Construction: ASME-code stainless steel with 150-psig (1035-kPa) minimum working-pressure rating.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

4. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Electronic anode system or replaceable magnesium anode.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
e. Jacket: Steel with enameled finish.
f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
g. Temperature Control: Adjustable thermostat.
h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Thermal Expansion Tanks:

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

a. AMTROL, Inc.
b. Smith, A. O. Corporation.
c. Watts.

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

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

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

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

D. Heat-Trap Fittings: ASHRAE 90.2.

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

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

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

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

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

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

2.3 SOURCE QUALITY CONTROL

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

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

C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Division 3.

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

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

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 “General-Duty Valves for Plumbing.”

C. Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 231123 "Facility Natural-Gas Piping."

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

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing."

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

H. Fill domestic-water heaters with water.

I. Charge domestic-water thermal expansion tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Supply Piping for Plumbing."

B. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping."

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

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

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION 22 34 00

SECTION 22 35 00

HEAT EXCHANGERS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Circulating, storage, domestic-water heat exchangers.
2. Brazed-plate, domestic-water heat exchangers.
3. Domestic-water, heat-exchanger accessories.

1.3 PERFORMANCE REQUIREMENTS

1.4 ACTION SUBMITTALS

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

B. Shop Drawings:

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

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of domestic-water heat exchanger, from manufacturer.

B. Domestic-Water, Heat-Exchanger Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic-water heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

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

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

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

1.8 COORDINATION

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

1.9 WARRANTY

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

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

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

2. Warranty Periods: From date of Substantial Completion.

a. Circulating, Storage, Domestic-Water Heat Exchangers:

1) Storage Tank: Three years.
2) Tube Coil: Three years.
3) Controls and Other Components: Three years.

b. Plate, Domestic-Water Heat Exchangers:

1) Brazed-Plate Type: Three year(s).
2) Plate-and-Frame Type: Three year(s).

c. Compression Tanks: Five year(s).

PART 2 - PRODUCTS

2.1 CIRCULATING, DOMESTIC-WATER HEAT EXCHANGERS

A. Circulating, Storage, Domestic-Water Heat Exchangers:

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

a. Cemline Corporation.
b. Patterson-Kelley.

c. RECO USA.
d. ThermaFlo Incorporated

2. Description: Packaged, large-capacity, hot-water storage tank with heat-exchanger coil; circulator; controls; and specialties for heating domestic water with heating hot water in coil.
3. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.
4. Storage-Tank Construction: ASME-code steel with 150-psig working-pressure rating. Include nozzle and head for heat-exchanger tube coil.

    a. Configuration: Vertical.
    b. Manhole: 11 by 15 inches in sidewall of vertical storage-tank shell.
    c. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.

        1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
        2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

    d. Lining: Complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
    e. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.
    f. Anode Rods: Electronic anode system or magnesium anodes.

5. Heat-Exchanger Coil: Vented, double-wall, copper or copper-alloy U tubes with tube sheet and supporting baffles. Include heat-exchanger pressure rating equal to or greater than heating-fluid supply pressure.
6. Temperature Control: Adjustable temperature aquastat, mounted in storage-tank shell head unless otherwise indicated.
7. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.
8. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
9. Gages: Factory-mounted thermometer and pressure gage.
10. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump. Include mechanical seals, 125-psig minimum working-pressure rating, and 225 deg F continuous-water-temperature rating.

    a. Pump Control: Sensor for operating pump and control valve.

11. Three-way Control Valve: Electronically Operated Control Valve, solid state sensor wired to electronic control module.

12. Factory mounted on skids.
13. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.

2.2 SOURCE QUALITY CONTROL

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

B. Hydrostatically test domestic-water heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER, HEAT-EXCHANGER INSTALLATION

A. Domestic-Water, Heat-Exchanger Mounting: Install domestic-water heat exchangers on concrete base. Comply with requirements for concrete bases specified in Division 3.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor heat exchangers to substrate.

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

1. Install shutoff valves on domestic-water-supply piping to heat exchangers and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing."

Retain first paragraph below if domestic-water heat exchangers are required to withstand seismic design loads. Insert special requirements for seismic restraints here or detail on Drawings.

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

D. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heat exchangers that do not have tank drains.

E. Install thermometer on each domestic-water, heat-exchanger, inlet and outlet piping. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing."

F. Fill domestic-water heat exchangers with water.

G. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Supply Piping for Plumbing."

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

C. Where installing piping adjacent to domestic-water heat exchangers, allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of domestic-water heat exchangers.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

B. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION 22 35 00

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SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Faucets for lavatories, showers and sinks.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Dishwasher air-gap fittings.
7. Disposers.
8. Water closets.
9. Urinals.
10. Lavatories.
11. Commercial sinks.
12. Wash fountains.
13. Individual showers.
14. Kitchen sinks.
15. Service basins.

B. Related Sections include the following:

1. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
2. Division 22 Section "Emergency Plumbing Fixtures."
3. Division 22 Section "Drinking Fountains and Water Coolers."

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

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

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

D. FRP: Fiberglass-reinforced plastic.

E. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

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

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

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

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

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

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

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

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

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

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

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

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Plastic Mop-Service Basins: ANSI Z124.6.
3. Plastic Shower Enclosures: ANSI Z124.2.
4. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
5. Vitreous-China Fixtures: ASME A112.19.2M.
6. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
7. Water-Closet, Flushometer Tank Trim: ASSE 1037.

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

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M. (coordinate with applicable codes)
3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
4. Faucets: ASME A112.18.1.
5. Hose-Connection Vacuum Breakers: ASSE 1011.
6. Hose-Coupling Threads: ASME B1.20.7.
7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.

8. NSF Potable-Water Materials: NSF 61.
9. Pipe Threads: ASME B1.20.1.
10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
11. Supply Fittings: ASME A112.18.1.
12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
3. Faucets: ASME A112.18.1.
4. Hand-Held Showers: ASSE 1014.
5. Hose-Coupling Threads: ASME B1.20.7.
6. Manual-Control Antiscald Faucets: ASTM F 444.
7. Pipe Threads: ASME B1.20.1.
8. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
9. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.

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

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Dishwasher Air-Gap Fittings: ASSE 1021.
4. Brass Waste Fittings: ASME A112.18.2.
5. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

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

1. Disposers: ASSE 1008 and UL 430.
2. Dishwasher Air-Gap Fittings: ASSE 1021.
3. Flexible Water Connectors: ASME A112.18.6.
4. Floor Drains: ASME A112.6.3.
5. Hose-Coupling Threads: ASME B1.20.7.
6. Off-Floor Fixture Supports: ASME A112.6.1M.
7. Pipe Threads: ASME B1.20.1.
8. Plastic Toilet Seats: ANSI Z124.5.
9. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

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

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

a. Structural failures of unit shell.
b. Faulty operation of controls, blowers, pumps, heaters, and timers.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: Three year(s) from date of Substantial Completion.

1.7 EXTRA MATERIALS

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

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

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

a. American Standard Companies, Inc. Commercial faucets
b. Chicago Faucets. Commercial faucets
c. Elkay Manufacturing Co. Commercial faucets
d. Kohler Co.
e. Moen, Inc. Commercial faucets
f. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: See fixture schedule on drawings for fixture description and model number. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

a. Body Material: Commercial, solid brass.
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 0.5 gpm (1.5 L/min.).
d. Centers: 4 inches (102 mm) Adjustable.
e. Mounting: Deck, exposed.
f. Inlet(s): NPS 1/2 (DN 15) male shank.
g. Spout: Rigid type.
h. Spout Outlet: Aerator.
i. Operation: Compression, manual.
j. Drain: Grid.
k. Tempering Device: Thermostatic.

2.2 SHOWER FAUCETS

A. Shower Faucets:

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

a. American Standard Companies, Inc.
b. Chicago Faucets.
c. Kohler Co.
d. Moen, Inc.
e. Symmons Industries, Inc.
f. Lawler Manufacturing Co., Inc.

2. Description: Single-handle thermostatic and pressure-balance valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.
3. See fixture schedule on drawings for complete description of fixture and accessories.

    a. Body Material: Solid brass with nonmetallic trim.
    b. Finish: Polished chrome plate.
    c. Maximum Flow Rate: 2.0 gpm (9.5 L/min.), unless otherwise indicated.
    d. Diverter Valve: Not required.
    e. Mounting: Concealed.
    f. Backflow Protection Device for Hand-Held Shower: Required.
    g. Operation: Compression, manual.
    h. Antiscald Device: Integral with mixing valve.
    i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
    j. Supply Connections: NPS 1/2 (DN 15) Sweat.
    k. Shower Head Type: Ball joint.
    l. Shower Head Material: Metallic with chrome-plated finish.
    m. Spray Pattern: Fixed.
    n. Integral Volume Control: Required.
    o. Shower-Arm Flow-Control Fitting: 2.0 gpm (7.6 L/min.).
    p. Temperature Indicator: Not required.

2.3 SINK FAUCETS

A. Sink Faucets:

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

    a. American Standard Companies, Inc.
    b. Chicago Faucets.
    c. Elkay Manufacturing Co.
    d. Just Manufacturing Company.
    e. Kohler Co.
    f. Moen, Inc.
    g. Speakman Company.
    h. T & S Brass and Bronze Works, Inc.
    i. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Kitchen faucet without spray Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
3. See fixture schedule on drawings for complete description of fixture and accessories.

    a. Body Material: Commercial, solid brass.
    b. Finish: Polished chrome plate.
    c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
    d. Backflow Protection Device for Hose Outlet: Required.
    e. Backflow Protection Device for Side Spray: Required.
    f. Inlet(s): NPS 1/2 (DN 15) male shank.
    g. Spout Outlet: Aerator.
    h. Drain: Grid.

2.4 FLUSHOMETERS

A. Flushometers:

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

   a. Sloan Valve Company.
   b. Zurn Plumbing Products Group; Commercial Brass Operation.
   c. Hydrotek International, Inc.

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

   a. Internal Design: Diaphragm operation.
   b. Style: Exposed.
   c. Trip Mechanism: Oscillating, lever-handle actuator.

2.5 TOILET SEATS

A. Toilet Seats:

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

   a. American Standard Companies, Inc.
   b. Bemis Manufacturing Company.
   c. Church Seats.
   d. Kohler Co.
   e. Olsonite Corp.
   f. Sperzel.

2. Description: Toilet seat for water-closet-type fixture.

   a. Material: Molded, solid plastic with antimicrobial agent.
   b. Configuration: Open front without cover.
   c. Size: Elongated.
   d. Hinge Type: CK, check.
   e. Class: Heavy-duty commercial.
   f. Color: White.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

   a. Engineered Brass Co.
   b. McGuire Manufacturing Co., Inc.
   c. TCI Products.
   d. TRUEBRO, Inc.
   e. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

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

2.7 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

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

C. Urinal Supports:

1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

E. Sink Supports:

1. Description: Type II, sink carrier with hanger plate, bearing studs, and tie rod for sink-type fixture. Include steel uprights with feet.

2.8 DISPOSERS

A. Disposers:

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

a. American Standard Companies, Inc.
b. In-Sink-Erator; a div. of Emerson Electric Co.
c. KitchenAid.
d. Maytag Co.

2. Description: Continuous-feed household, food-waste disposer. Include reset button; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless-steel grinder or shredder; NPS 1-1/2 (DN 40) outlet; quick-mounting, stainless-steel sink flange; antisplash guard; and combination cover/stopper.

3. See fixture schedule on drawings for complete description of fixture and accessories.

a. Type: Continuous-feed household.
b. Model: Sound-insulated chamber and stainless-steel outer shell.
c. Motor: 115-V ac, 1725 rpm, 1 hp with overload protection.

2.9 WATER CLOSETS

A. Water Closets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Plumbing, L.L.C./Fiat Products.
b. American Standard Companies, Inc.
c. Kohler Co.
d. Zurn

2. Description Accessible, Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
3. See fixture schedule on drawings for complete description of fixtures and accessories.

a. Style: One piece.

1) Bowl Type: Elongated with siphon-jet design.
2) Design Consumption: 1.6 gal. /flush (6 L/flush).
3) Color: White.

b. Style: Flushometer valve.

1) Bowl Type: Elongated with siphon-jet design.
2) Design Consumption: 1.6 gal. /flush (6 L/flush).
3) Color: White.

c. Fixture Support: Water-closet support combination carrier.

2.10 URINALS

A. Urinals:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Crane Plumbing, L.L.C./Fiat Products.
c. Eljer.
d. Kohler Co.
e. Zurn

2. Description: Accessible, wall hung, back-outlet, vitreous-china fixture designed for flushometer valve operation.
3. See fixture schedule on drawings for complete description of fixture and accessories.

a. Type: Siphon jet.
b. Strainer or Trapway: Integral cast strainer with integral trap.
c. Design Consumption: 0.5 gal./flush (1.9 L/flush).
d. Color: White.
e. Supply Spud Size: NPS 3/4 (DN 20)

f. Outlet Size: NPS 2 (DN 50).
g. Flushometer:
h. Fixture Support: Urinal Floor mounted chair carrier.

2.11 LAVATORIES

A. Lavatories:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Kohler Co.
c. Crane Plumbing, L.L.C./Fiat Products.

2. Description: See fixture schedule on drawings for complete description of fixture and accessories.

2.12 COMMERCIAL SINKS

A. Commercial Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Elkay Manufacturing Co.
b. Just Manufacturing Company.
c. Metal Masters Foodservice Equipment Co., Inc.

2. Description: See fixture schedule on drawings for fixture description, counter-mounting, stainless-steel commercial sink with backsplash.

2.13 WASH FOUNTAINS

A. Wash Fountains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acorn Engineering Company.
b. Bradley Corporation.
c. Intersan Manufacturing Company.

2. Description: See fixture schedule on drawings for complete description of fixture and accessories.
3. Semicircular design, wash-up fixture.

a. Arrangement: Wash-up stations facing central spray head.
b. Receptor Material: Stainless steel on base.

2.14 KITCHEN SINKS

A. Kitchen Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: See fixture schedule on drawings for complete description of fixture and accessories.

a. Kohler Co.
b. American Standard Companies, Inc.

c. Dayton Products, Inc.
d. Elkay Manufacturing Co.
e. Just Manufacturing Company.

2. Description See fixture schedule on drawings for complete description of fixture and accessories.

2.15 SERVICE SINKS

A. Service Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Kohler Co.
c. Crane Plumbing, L.L.C./Fiat Products.
d. Mustee
e. Fiat
f. Kohler Co.

2. Description See fixture schedule on drawings for complete description of fixture and accessories

2.16 SERVICE BASINS

A. Service Basins:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Plumbing, L.L.C./Fiat Products.
b. Florestone Products Co., Inc.
c. Precast Terrazzo Enterprises, Inc.
d. Stern-Williams Co., Inc.
e. Mustee, E. L. & Sons, Inc.

2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard. See fixture schedule on drawings for complete description of fixture and accessories.

a. Shape: Square.
b. Rim Guard: On all top surfaces.
c. Color: Not applicable.
d. Drain: Grid with NPS 3 (DN 80) outlet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install trap-seal liquid in dry urinals.

P. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

Q. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

R. 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.

S. Install shower flow-control fittings with specified maximum flow rates in shower arms.

T. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

U. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

V. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck. Connect inlet hose to dishwasher and outlet hose to disposer.

W. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

X. Set shower receptors and service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

Y. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

E. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 40 00

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SECTION 22 45 00

EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following emergency plumbing fixtures:

1. Combination units.
2. Water-tempering equipment.

B. Related Sections include the following:

1. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Tepid: Moderately warm.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For emergency plumbing fixtures to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

PART 2 - PRODUCTS

2.1 COMBINATION UNITS

A. Combination Units:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bradley Corporation.
   b. Guardian Equipment Co.
   c. Haws Corporation.
   d. Speakman Company.

2. Description: See fixture schedule on drawings for complete description of fixture and accessories. Plumbed, accessible, freestanding, with emergency shower and eye/face wash equipment.
   a. Piping: Galvanized steel.

      1) Unit Supply: NPS 1-1/2 (DN 40) from top.
      2) Unit Drain: Outlet at side near bottom.
      3) Shower Supply: NPS 1 (DN 25) with flow regulator and stay-open control valve.
      4) Eye/Face Wash Supply: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.

   b. Shower Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.

      1) Control-Valve Actuator: Pull rod Treadle.
      2) Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel.

   c. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.

2.2 WATER-TEMPERING EQUIPMENT

A. Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Haws Corporation.
   b. Lawler Manufacturing Co., Inc.
   c. Leonard Valve Company.
   d. Speakman Company.

2. Description: Factory-fabricated, hot- and cold-water-tempering equipment with thermostatic mixing valve.

   a. Thermostatic Mixing Valve: Designed to provide 75 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.

2.3 SOURCE QUALITY CONTROL

A. Certify performance of plumbed emergency plumbing fixtures by independent testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency plumbing fixture.
2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Dielectric fittings are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Thermometers are specified in Division 22 Section "Meters and Gages for Plumbing Piping."

G. Install indirect waste piping to wall on drain outlet of fixture receptors that are indicated to be indirectly connected to drainage system. Drainage piping is specified in Division 22 Section "Sanitary Waste and Vent Piping."

H. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

I. Install equipment nameplates or equipment markers on fixtures and equipment signs on water-tempering equipment. Identification materials are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot- and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities and temperatures.

B. Electrical-Component Testing: After electrical circuitry has been energized, test for compliance with requirements.

1. Test and adjust controls and safeties.

C. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

D. Report test results in writing.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION 22 45 00

SECTION 22 47 00

WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following drinking fountains and water coolers and related components:

1. Pressure water coolers.
2. Fixture supports.

1.3 DEFINITIONS

A. Accessible Water Cooler: Fixture that can be approached and used by people with disabilities.

B. Cast Polymer: Dense, cast-filled-polymer plastic.

C. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

D. Fitting: Device that controls flow of water into or out of fixture.

E. Fixture: Drinking fountain or water cooler unless one is specifically indicated.

F. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

D. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.

E. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetra-fluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Water Coolers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Elkay Manufacturing Co.
   b. Halsey Taylor.
   c. Haws Corporation.
   d. Oasis Corporation.

2. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler for adult -mounting height.

   a. Cabinet: Bi-level with two attached cabinets, all stainless steel.
   b. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
   c. Bottle filler Yes
   d. Control: Push bar.
   e. Supply: NPS 3/8 (DN 10) with ball, valve.
   f. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
   g. Drain(s): Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.1.
   h. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
   i. Capacity: See fixture schedule on drawings for fixture capacities and characteristics Support: Type II, water cooler carrier. Refer to "Fixture Supports" Article.

2.2 FIXTURE SUPPORTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Josam Co.
2. MIFAB Manufacturing, Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.

C. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.

1. Type II: Bilevel, hanger-type carrier with three vertical uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install fixtures level and plumb. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

C. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

D. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.

1. Remove and replace malfunctioning units and retest as specified above.
2. Report test results in writing.

3.6 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 22 47 00

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACCURACY OF DATA AND CONTRACT DRAWINGS

A. The design drawings are diagrammatic and they may not show all physical arrangements, offsets, bends, or elbows which may be required for installation of various materials, equipment, piping, and ductwork systems in allotted spaces. The Contractor shall examine these and other available drawings to determine space limitations and interferences. The Contractor shall be responsible for making any minor changes in location of equipment, pipe and ductwork from that shown on drawings and for all physical details required for installation. Cost for adapting Contractor's work to jobsite conditions shall not be considered as basis of an extra cost to contract. The Contractor shall get approval before proceeding with any change.

B. Elevation of piping, ductwork and equipment indicated on drawings are to be used as guidelines to assist Contractor with installations. Minor changes to these elevations may be necessary to eliminate unforeseen interferences. The Contractor shall get approval before proceeding with any significant changes in elevations.

C. Information pertaining to new and existing conditions that are described in the specifications or appear on drawings are based on available records. While such data has been collected with reasonable care, there is no expressed or implied guarantee that conditions so indicated are entirely representative of those actually existing or that unlooked for developments may not occur. Such information is merely provided to assist the Contractor in his investigation of conditions.

D. The Contractor must carefully examine the drawings, specifications and project site, and verify all measurements, distances, levels, materials, equipment, etc. before starting work.

E. Drawings shall not be scaled for determining exact dimensions or location of equipment.

F. Except as otherwise specified herein or indicated on drawings, furnish and install all piping, tubing, valves, specialties and supports to connect fixtures and equipment into their respective systems as required for or incidental to the proper operation of the indicated systems.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: None

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. The Contractor or the Contractor's authorized representative must be present to accept delivery of all equipment and materials furnished by him. The Owner's personnel will not knowingly accept, unload or store anything delivered to the site for the Contractor's use. Inadvertent acceptance of delivered items by a representative of the Owner shall not constitute acceptance or responsibility for any of the materials or equipment. It shall be the Contractor's responsibility to assume all liability for any equipment or materials furnished by him which are delivered to the job site.

D. Storage of materials on the grounds and within the building shall be in strict accordance with instructions of the Owner. Storage of materials within building shall at no time exceed design carrying capacity of the structural system.

E. The Owner assumes no responsibility for materials stored in building or on the site. Each Contractor shall assume full responsibility for all losses or damage due to the storing of his materials.

F. Handle items carefully to avoid damage to components, enclosures and finishes. Follow the manufacturer's rigging instructions when handling and moving equipment.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.8 CODES AND REGULATIONS

A. All codes and regulations of state and local authorities shall become part of this specification and must be adhered to where they exceed requirements as shown on the drawings or stated in the specifications, without additional cost to the Contract.

1.9 CONTINUITY OF EXISTING SERVICES

A. Do not interrupt or change existing services without prior written approval. When interruption is required, coordinate length of service time with Owner to minimize disruption of occupant activities.

1.10 OPERATING AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall provide operating and maintenance instruction manuals covering each and every item of equipment and devices furnished or erected by the Contractor prior to "Substantial Completion" as required by Division 1.

B. Each separate manual shall consist of the following:

1. Neatly typewritten table of contents including contractor's name, address and telephone number; list of each product referenced in manual; and name, address and telephone number of installing contractor and maintenance contractor for each product.
2. Tabbed sections of catalog data and literature for each product including model number, description and component parts; operating procedures; maintenance procedures; servicing and lubrication schedules; description of sequence of operations; parts lists; illustrations, assembly drawings and diagrams required for maintenance; any additional drawings, diagrams, charts or written text which may be required to supplement product data for particular installation; certified test and balance report; list of control point labels, and wiring diagrams.
3. Copy of warranty, bond and/or service contract issued for each product including an information sheet for operations personnel with proper procedures in event of a product failure and instances which might affect validity of warranties or bonds.
4. Full size sheets, if required, shall be folded into special holding pockets. Faxed, handwritten, or illegible materials are not acceptable.

C. Prior to final inspection or acceptance, fully instruct designated facility operating and maintenance personnel on operation, adjustment and maintenance of products, equipment and systems. Review contents of operating and maintenance manual with personnel in full detail to explain all aspects of operations and maintenance.

1.11 POSTED OPERATIONS INSTRUCTIONS (POIs)

A. Provide comprehensive posted operations instructions for all equipment and systems. Instructions shall be developed as CADD schematics, files, or plans and include printed text. Information shall include but not limited to air system schematics, water system schematics, equipment schedules, valve charts, controls points list, sequence of operations, and building plan showing equipment locations. They shall be framed under glass with extruded metal

frame and shall be bolted to the mechanical room wall. Instructions shall be in color and use color graphics for illustrative purposes.

B. As an alternative to posting in mechanical rooms, POIs may be incorporated into the graphics package of the base central Energy Management and Control System (EMCS).

1.12 PROTECTION OF ROOF

A. Contractors are cautioned that they must exercise extreme care in any activity involving contact with any installed roof membrane.

B. Construct protective plywood (3/4 in. thick) runways across the roof for moving, setting, and installing equipment and piping systems. No activity on the roof will be permitted without this protection. Start runways at the point of origin of any equipment placed on roof and terminate at the point of installation on curb or base. At completion of work, or when directed by the Owner, completely remove, neatly and cleanly, without damage to roofing system, these protective items and runways.

C. Any and all repairs necessary to bring the roofing system to its original condition shall be made by an approved Roofing Contractor and paid for by the Contractor responsible for the damage

1.13 WORK COORDINATION

A. All Trades shall work in cooperation with each other, and fit their work into the structure as job conditions may demand. All final decisions as to right-of-way and run of pipes and ducts, etc. shall be made by the Owner. In general, priority shall be arranged as follows: (in order of preference)

1. Recessed lighting fixtures
2. Piping which must be drainable
3. Sheet metal ductwork
4. Lighting fixtures
5. Plumbing waste lines, downspouts, vents and sprinkler piping
6. Gravity water lines
7. Heating hot lines
8. Refrigerant lines
9. Plumbing water and gas and air lines
10. Electrical conduit
11. Control wiring conduit

1.14 INSPECTION

A. The Contractor shall verify the location of underground service, utilities, structures, etc., which may be encountered or be affected by his work and shall be responsible for any damage caused by neglect to provide proper precautions or protection.

B. Any work that is to be concealed, such as inside walls, above ceilings, soffits, shall be inspected by Owner and/or Architect/Engineer prior to concealment

1.15 TEMPORARY HVAC

A. Occupied Spaces: Provide temporary heating, ventilation, and air conditioning in occupied areas when HVAC cannot be provided from existing or new systems as designed. A minimum of 0.5 cfm/ft^2 ventilation air shall be provided. When heating, the system shall maintain the room temperature at 68°F or warmer. When cooling, the system shall maintain the room temperature at 78°F or cooler and maintain the relative humidity below 60%. Existing systems may be modified to meet these requirements. Direct-fired heaters are not permitted. All temporary HVAC provisions must be approved. Visible portions, such as diffusers, grilles, thermostats, and any exposed ductwork, must also be approved.

B. In normally unoccupied spaces that are only heated, provide temporary heating to maintain the temperature at 55°F or warmer. Use of direct-fired heaters is acceptable, provided ventilation is adequate and condensation is minimized. Any damage from condensation shall be repaired by this contractor at no additional cost to the Contract.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8-inch-thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Available Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Available Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Available Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Available Manufacturers:

a. Calpico, Inc.
b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Available Manufacturers:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.5 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space

1. Available Manufacturers:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.7 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Stamped-Steel Type: With spring clips and chrome-plated finish.

D. Split-Plate, Stamped-Steel Type: With concealed hinge, spring clips, and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.9 SEALANTS

A. Reference Division 7 specification for sealant requirements

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Full lengths of pipe shall be used. Short lengths and couplings will not be permitted.

L. Where more than one pipe material specification or valve is allowed for particular service, the Contractor is required to use one and only one of the pipe materials specified throughout project. Two or more different piping materials or valves for same service will not be allowed unless indicated otherwise on drawings or specified herein.

M. Independently support piping so that its weight shall not be supported by the equipment to which it is connected.

N. Size reduction shall be made using reducing fittings; bushings are not acceptable.

O. Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.

P. "Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (1/2) the diameter of the main.

Q. Cover ends of piping during installation to keep inside of piping clean.

R. Piping shall not be routed through electrical rooms or transformer vaults, or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

S. Use only wrenches having square flat jaws, or non-metallic strap wrenches on brass specialties; wrench marks not permitted.

T. Select system components with pressure rating equal to or greater than system operating pressure.

U. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Insulated Piping: One-piece, stamped-steel type with spring clips.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
e. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and spring clips.
f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with spring clips.
g. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

V. Sleeves are not required for core-drilled holes thru solid concrete walls.

W. Permanent sleeves are not required for holes formed by removable PE sleeves.

X. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

Y. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Z. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

AA. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

BB. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

CC. Verify final equipment locations for roughing-in.

DD. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

EE. Vent Piping (aboveground):

1. Install vent and relief valve discharge lines as indicated on the drawings, as detailed, and as specified for each specific valve or piping specialty item. In no event is a termination to occur less than six feet above a roof line.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 23 05 00

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. 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 740 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Shaft Grounding: Provide bearing protection grounding rings to bleed current from the motor shaft to the motor casing.

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.

2.6 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Description: Electrically commutated, adjustable speed, brushless dc (BLDC) motor.

B. Constant CFM, constant torque

C. Multi-Speed: Shall be speed controllable down to 20% of full speed using a 0-10 VDC signal.

D. Efficiency: Energy efficient, as defined in NEMA MG 1.

E. Service Factor: 1.00

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 05 13

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SECTION 23 05 14

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 COORDINATION

A. Coordinate features of variable frequency drives, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.
2. Ratings and characteristics of supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.

1. Include dimensions and finishes for VFDs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each VFD from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the following as City of Madison's preferred variable frequency drive equipment supplier and is to be a part of the Section 230900 Contractor's scope of work for this project.

1. Danfoss Model VLT

2.2 DESIGN AND CONSTRUCTION

A. The unit shall be variable torque, modular design for control of the motors as specified in Division 23 and rated at the motor full load nameplate amps.

B. The unit shall be U.L. listed, solid state, microprocessor-based with an 18 pulse width modulated (PWM) output wave form (none others are acceptable).

C. The VFD shall employ a full wave bridge rectifier and capacitors to minimize the ripple of the rectified voltage to maintain near constant DC voltage. Insulated gate bipolar transistors (IGBT's) shall be employed as the output switching device.

D. The VFD package shall contain the equivalent of 5% impedance to reduce harmonic distortion. The 5% equivalent impedance shall be provided in the form of a DC bus choke, an input AC line reactor in each phase, or a combination of the two methods.

E. Control circuitry shall be plug-in, plug-out modular basis with a corrosion resistant coating on printed circuit boards.

F. Units to be suitable for an operating environment from 0°C to 40°C temperature and humidity up to 90% non-condensing.

G. Electrically and physically isolate control circuitry and conductors from power circuitry and power conductors. Control conductors and power conductors shall not be run in the same pathway.

H. The unit enclosure shall be NEMA 1 as required for the application minimum and all components shall be fully factory assembled and tested prior to leaving the manufacturing facility.

I. Include the following operating and monitoring devices mounted on the front cover:

1. A disconnect switch or circuit breaker to de-energize the drive circuit with door interlocked handle and lock-open padlocking provisions.
2. Operating mode selector switch marked "hand-off-auto".
3. Manual speed adjustment via keypad, mounted on the door.

2.3 PERFORMANCE REQUIREMENTS

A. Units shall be suitable for input power of electrical system as scheduled on the drawings ±10%, 3 phase, 60 Hertz nominal.

B. Use a current limiting control device to limit output current to 110% continuous for one minute; also refer to Protection Features in this section. Full load output current available from drive shall not be less than motor

nameplate amperage. The full load amp rating of the VFD shall not be less than the values indicated in the NEC Table 430-150.

C. Output power shall be suitable for driving standard NEMA B design, three phase alternating current induction motors at full rated speed with capability of 6:1 turndown.

D. Additional performance capabilities to include the following:

1. Ride through a momentary power outage of 15 cycles,
2. Start into a rotating load without damage to drive components or motor,
3. Capable of automatic restart into a rotating load after a preset, adjustable time delay following a power outage
4. Input power factor: Min 0.95 throughout the speed range
5. Minimum efficiency: 95% at 100% speed, 85% at 50% speed

2.4 CONTROL FEATURES

A. Use control circuits compatible with input signal from temperature control system in the automatic mode and from manual speed control in the manual mode. Vary motor speed in response to the input control signal. Include components necessary to accept the signal from the temperature control system in the form that it is sent.

B. Include the following additional control features:

1. Hand-Off-Automatic (HOA) selector switch to select local or remote start/stop and speed control.
2. Analog input, selectable 0-10v or 4-20 mA, for automatic control from the temperature control system.
3. Local speed control at the VFD.
4. Adjustable acceleration and deceleration rate so that the time period from start to full speed and from full speed to stop can be field adjusted.
5. Adjustable minimum and maximum speed settings for both automatic and manual modes of operation.
6. Field adjustment of minimum and maximum output frequency.
7. Two (2) sets of programmable form “C” contacts for remote indication of variable frequency drive condition. Note: default programming to be set for “Drive Run & Fault”.
8. Illuminated display keypad.
9. External Fault indicator.
10. One (1) input for a N.O. dry contact type input for a 2-wire remote start/stop.
11. One (1) input for a N.C. dry contact type input for external faults: (freezestats, fire alarm, smokes, etc). This input shall be factory wired to prevent VFD when external fault is present.
12. One (1) N.O. dry contact output for proving motor status. This output shall be programmed to detect belt or coupling break that would remove the load from the motor. The dry contact will open on loss of load or VFD being off.
13. PID control loop capable of VFD control from an external device connected to a VFD analog input.

C. The VFD controller shall convert VFD information into the BACnet MSTP protocol that will be compatible with the building direct digital energy management system (EMS) supplied on the project. This output shall be through a serial interface port capable of two-way communication with the building EMS provided on this project. Final connection shall not require any additional intermediate gateway devices to provide throughput of data. The following data shall be provided at a minimum:

1. Fault condition
2. Speed
3. Amperage
4. Frequency
5. Voltage

2.5 PROTECTION FEATURES

A. Use electronic protection circuitry in the power circuits to provide an orderly shutdown of the drive without blowing fuses or tripping circuit breakers and prevent component loss under the following abnormal conditions:

1. Activation of any safety device;
2. Instantaneous overcurrent and/or over voltage of output;
3. Power line overvoltage and undervoltage protection;
4. Phase loss;
5. Single and three phase short circuiting;
6. Ground faults;
7. Control circuit malfunction;
8. Overtemperature; and
9. Output current over limit.

B. Provide the following additional protective features:

1. Input transient overvoltage protection up to 3000 volts per ANSI 37.90A;
2. DC bus fusing or other electronic controls which limit the rate of rise of the DC bus current and de-energizes the drive at a predetermined current level;
3. Fusing for the control circuit transformer;
4. Grounded control chassis; and

2.6 DIAGNOSTICS

A. Provide an English character display (no error codes) with indicators for the following:

1. Phase loss
2. Ground fault
3. Overcurrent
4. Overvoltage
5. Undervoltage
6. Over temperature
7. Overload
8. DC bus status

2.7 QUALITY ASSURANCE TESTS

A. Use a factory heat stress test to verify proper operation of all functions and components under full load.

B. Field performance test of variable frequency drives to determine compliance with this specification will be performed at the Owner’s discretion and may include any specified feature, including operation of protective devices through a simulated fault. Contractor will pay for initial testing. Should drive be found deficient by this testing, drive manufacturer will be required to make any and all changes necessary to bring unit(s) into compliance with the specified performance and demonstrate this performance by retesting. Cost of changes and retest will be by this contractor.

C. Variable frequency drive manufacturer or designated representative to perform a field test of each drive, in the presence of the Owner's representative, for the following items:

1. Provide general inspection to verify proper installation;
2. Demonstrate drive reaction to simulated power interruptions of two seconds and sixty seconds;

2.8 AC INPUT LINE REACTORS

A. When needed to comply with the requirement for 5% equivalent impedance, furnish and factory install AC input line reactors.

B. Line reactors shall be installed in each phase of the AC input side of the VFD and mounted within a common enclosure with the VFD.

C. Line reactor shall be a three-phase inductor, iron core, 600V, Class H insulation, 115 degree C rise, copper windings with screw type terminal blocks.

PART 3 - EXECUTION

3.1 VARIABLE FREQUENCY DRIVES

A. Install where indicated on drawings and in accordance with approved submittals and manufacturer's published recommendations. Installation to be by the Division 26 - Electrical contractor.

B. Input power wiring shall be installed in a separate conduit, output power wiring shall be installed in a separate conduit and control wiring shall be installed in a separate conduit. Do not mix input power, output power, or control wiring in a common conduit. Separate conduits for input and output power wiring shall be provided for each motor. Input and output power wiring for more than one motor shall not share a common conduit. Power wiring shall be furnished and installed by the Div. 26 contractor. If provided, do not mount output line filter above the drive.

C. Control signal for drive will be provided under Division 23.

D. Temperature Control Contractor will furnish and install the required temperature control wiring in metal conduit and in accordance with Division 26 of this specification.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFDs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.4 PROTECTION

A. Replace VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

END OF SECTION 23 05 14

SECTION 23 05 19

METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ashcroft Inc.
    b. Miljoco Corporation.
    c. Trerice, H. O. Co.
    d. Weiss Instruments, Inc.

B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.

E. Connector Type(s): Union joint, adjustable angle with unified-inch screw threads.

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 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.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ashcroft Inc.
    b. Miljoco Corporation.
    c. Trerice, H. O. Co.
    d. Weiss Instruments, Inc.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inchnominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Plastic.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston -type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Flow Design, Inc.
2. Miljoco Corporation.
3. Trerice, H. O. Co.
4. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
5. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install test plugs in piping tees.

K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

L. Install permanent indicators on walls or brackets in accessible and readable positions.

M. Install connection fittings in accessible locations for attachment to portable indicators.

N. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.

2. Inlet and outlet of each hydronic boiler.
3. Inlet and outlet of each hydronic coil in air-handling units.

O. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

END OF SECTION 23 05 19

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.4 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.
4. Set butterfly valves closed or slightly open.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

1.6 EXTRA MATERIALS

A. Provide two repacking kits for each size and valve type.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

B. Valve Sizes: Same as upstream piping unless otherwise indicated.

C. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 6 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 5and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve gear actuator or handwheel; with chain for mounting height, for valves located 12 feet or higher from floor.

D. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
2. Butterfly Valves: With extended neck.

E. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Threaded: With threads according to ASME B1.20.1.

F. Valve Bypass and Drain Connections: MSS SP-45.

G. The manufacturer's name and valve pressure rating shall appear on the outside of the valve body.

2.2 BRONZE BALL VALVES

A. 2" and smaller: Two-piece bronze body; threaded or soldered ends, as appropriate to the pipe material; stainless steel or chrome plated brass/bronze ball; conventional port; glass filled teflon seat; threaded packing gland follower; blowout-proof stem; 600 psig WOG.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo 70-100/200 series
b. Hammond 8301/8311
c. Milwaukee BA100/150
d. Nibco T/S 585-70
e. Stockham S206/216.

2. Description:

   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

3. 2½" and over: The above manufacturers of ball valves will not be accepted in sizes over 2 inch. American Valve is only accepted ball valves as noted below.

2.3 CAST IRON, FLANGED BALL VALVES

A. Class 125, Iron Ball Valves: 2½" and larger: Use American Valve ball valves for flanged connections in lieu of butterfly valves at all branch services lines.

1. Basis-of-Design Product: Subject to compliance with requirements, provide the following as City of Madison's preferred ball valve manufacturer supplier for 2½" and larger.

   a. American Valve: 4000 Flanged ball valve.

2. Cast iron body; stainless steel shaft; flanged ball valve with Cast Iron/PFA fused ball, blow-out proof stem, full port with Lockable in Full Open or Closed Positions lockable in full open or closed positions. Rated for 150 WSP 300 WOG.

3. Description:

   a. Standard: MSS SP-72.
   b. CWP Rating: 200 psig
   c. Body Design: Split body.
   d. Body Material: ASTM A 126, gray iron.
   e. Ends: Flanged.
   f. Seats: PTFE or TFE.
   g. Stem: Stainless steel.
   h. Ball: Stainless steel.
   i. Port: Full.

2.4 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Red-White Valve Corporation.

2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 200 psig.

c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

2.5 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Red-White Valve Corporation.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.

2.6 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hammond Valve.
b. Metraflex, Inc.
c. Milwaukee Valve Company.
d. Mueller Steam Specialty; a division of SPX Corporation.
e. NIBCO INC.
f. Spence Strainers International; a division of CIRCOR International.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12
c. CWP Rating: 200 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Compact wafer.
f. Seat: Bronze.

2.7 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball, butterfly, and plug valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, Ductile or cast iron, Cast iron, or Aluminum Bronze, of type and size required for valve. Include zinc coating.
4. Chain: Hot-dip, galvanized steel or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chain wheels on operators for butterfly, NPS 4 and larger and more than 144 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

G. Install shutoff valves in all branch lines at or near header and at each automatic valve location.

H. Vents and Drains: All required vents and drains may not be shown on the Contract Drawings. Install 3/4-inch nominal size vent and drain valves in piping systems 1-inch and larger. Install line size vent and drain valves in piping systems 3/4 inch and smaller. Locate vents at high points of each line and/or branch connection. Locate drains at low points. Use piping materials specified for each service. Cap all vents and drains.

1. Use ball valve with threaded hose adapter and chained cap. Strainer blowdown valves shall be same size as strainer blowdown connection.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, or butterfly valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with nonmetallic disc.
    b. NPS 2-1/2 and Larger: iron, center-guided, seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. See drawing valve schedule for valve application requirements.

D. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated.
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.

END OF SECTION 23 05 23

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. Flex-Strut Inc.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut Corporation; Tyco International, Ltd.
    g. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: Hot-dipped galvanized.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

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. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless- steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Plastic.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. 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.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. 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.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating 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.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

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 thermal-hanger shield inserts for insulated piping and tubing.

G. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

H. 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.

I. 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.

J. 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.

K. 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.

L. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29

SECTION 23 05 48

VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For testing agency.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.5 PERFORMANCE REQUIREMENTS

1.6 VIBRATION CONTROL DESIGN CRITERIA

A. Isolate all motor driven and reciprocating mechanical equipment unless otherwise noted, from building structure, and from systems which they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow ASHRAE Application Handbook - Sound and Vibration Control, latest edition or manufacturer's recommendations for isolation selection.

B. Select and locate isolators to produce uniform loading and deflection. Use minimum of four isolators to support each piece of equipment.

C. Select vibration isolation devices based on lowest operating speed.

D. Vibration Criteria:

E. All rotating equipment shall operate at speeds less than 80% of their true critical speed. Unless otherwise required, equipment shall be balanced according to the recommendations given in the following schedules.

1. Vertical vibration of rotating equipment shall not be greater than levels indicated. Vibration shall be measured on equipment or steel-frame equipment base when equipment is mounted on its vibration isolation mounts. If equipment has inertia base, allowable vibration level is reduced by ratio of equipment weight alone to equipment weight plus inertia base weight.

Equipment Speed RPM	Maximum Allowable Vibration Displacement Peak-to-Peak (mil)
Under 600	4
600 to 1000	3
1000 or 2000	2
over 2000	1

2. Following field installation, each fan over 5 HP shall be balanced in accordance with the following schedule:

   a. Centrifugal fans - 25 mil/sec, rms

3. Final in-field balance shall be measured with each fan over 5 HP installed on springs specified for unit. Fans shall be loaded with design static pressure. Measurement shall be carried out in vertical axis at each corner of frame supporting fan/motor assembly.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS (TYPE 1)

A. Elastomeric Isolation Pads

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. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: [Smooth] [Ribbed] [Waffle] pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: [Resilient] [and] [elastomeric] <Insert compound>.

a. Surface Pattern: [Smooth] [Ribbed] [Waffle] pattern.
b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS (TYPE 2)

A. Double-Deflection, Elastomeric Isolation Mounts:

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. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 OPEN-SPRING ISOLATORS (TYPE 3)

A. Freestanding, Laterally Stable, Open-Spring Isolators:

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. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.4 HOUSED-SPRING ISOLATORS (TYPE 4)

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

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. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibration Eliminator Co., Inc.
    g. Vibration Isolation.
    h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt, threaded mounting holes and internal leveling device and elastomeric pad.

2.5 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.6 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.
1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.7 ELASTOMERIC HANGERS (TYPE H2)

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: Retain "Manufacturers" Subparagraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.

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. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibration Eliminator Co., Inc.
    g. Vibration Mountings & Controls, Inc.

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. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.8 SPRING HANGERS (TYPE H3)

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Kinetics Noise Control, Inc.
    d. Mason Industries, Inc.
    e. Vibration Eliminator Co., Inc.
    f. Vibration Isolation.
    g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.9 VIBRATION ISOLATION EQUIPMENT BASES

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. California Dynamics Corporation.
2. Kinetics Noise Control.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation.
6. Vibration Mountings & Controls, Inc.

B. Steel Rails (Type B1): Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases (Type B2): Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base (Type B3): Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.3 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

3.4 VIBRATION ISOLATION SCHEDULE

A. Air-Cooled Condensing Units (Exterior)

1. Base: Type B1
2. Isolator: Type 4, 1.5 inches deflection

B. Air-Cooled Condensing Units (Indoor)

1. Base: Type 1
2. Isolator: None

C. Unit Heaters

1. Base: None
2. Isolation: Type H2, 0.75 inches deflection

D. Exhaust Fans

1. Base: None
2. Isolation: Type H3, 0.75 inches deflection

E. Pumps HWP-1, HWP-2, HWP-3 and HWP-4

1. Base: Type B3
2. Isolator: Type 3, 1.75 inches deflection

END OF SECTION 23 05 48

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SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

1.3 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
2. Letter Color: White
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 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 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: Adhesive or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.3 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inchnumbers.

1. Tag Material: Brass, 0.032-inchminimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.4 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 05 53

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 60 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. 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.

C. Certified TAB reports.

D. Sample report forms.

E. 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.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.

B. TAB Conference: Meet with Owner, Construction team, Commissioning Authority and Engineer on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, available TAB contractors that may be engaged include, but are not limited to, the following:

1. Balco Balancing, Inc.
2. Badger Balancing LLC
3. Environmental System Analysis
4. Professional System Analysis, Inc

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

E. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and filters and verify that bearings are greased, and equipment with functioning controls is ready for operation.

I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. 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.

3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.

4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", or ASHRAE 111 or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and/or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow:

    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fan's VFD or ECM motor to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

    a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.
9. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

10. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

C. Motors Driven by Electronically Commutated Motor (ECM): Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.12 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.13 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

3.14 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each refrigerant and hot gas reheat 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. Refrigerant suction pressure and temperature.

3.15 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.
5. Solar Heating-Water Flow Rate: Plus or minus 10 percent.

3.16 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 systems' balancing devices. Recommend changes and additions to systems' 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.

3.17 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.

c. Cooling coil, wet- and dry-bulb conditions.
d. Face and bypass damper settings at coils.
e. Fan drive settings including settings and percentage of maximum pitch diameter.
f. Settings for supply-air, static-pressure controller.
g. Other system operating conditions that affect performance.

D. Make-Up and Air-Handling-Unit Test Reports: For units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.

E. 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. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.

F. 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.

2. Motor Data:

   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.

3. Test Data (Indicated and Actual Values):

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

G. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

   a. System and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft.
   g. Indicated air flow rate in cfm.
   h. Indicated velocity in fpm.

i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

H. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Air velocity in fpm.
c. Preliminary air flow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final air flow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

I. System-Coil Reports: For water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

J. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.

f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

3.18 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.19 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

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. LEED Submittals:

C. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

D. 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.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "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.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. See drawing schedule(s) for insulation material specifications.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II with factory-applied FSK jacket. Minimum nominal density of 0.75 lbs. per cu. ft., and thermal conductivity of not more than 0.30 at 75 degrees F mean temperature, rated for maximum service temperature of 250 degrees F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. CertainTeed Corp.; SoftTouch Duct Wrap.
    b. Johns Manville; Microlite.
    c. Knauf Insulation; Friendly Feel Duct Wrap.
    d. Manson Insulation Inc.; Alley Wrap.
    e. Owens Corning; SOFTR All-Service Duct Wrap.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ with nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F mean temperature, 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 maximum service temperature of 450 degrees F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Ownens Corning: Thermafiber VersaBoard
b. Fibrex Insulations Inc.; FBX.
c. Johns Manville; 800 Series Spin-Glas.
d. Knauf Insulation; Insulation Board.
e. Manson Insulation Inc.; AK Board.
f. Owens Corning; Fiberglas 700 Series.

2. Insulating contractor shall use 6 or 8 per cu. Ft. mineral-fiber board when using with field applied self-adhesive indoor/outdoor Jacket. Install per manufacturer's guidelines for appropriate type of self-adhesive indoor/outdoor jacket. See drawing schedule(s) for insulation material specifications.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.

b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
b. Vimasco Corporation; 713 and 714.

2. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
c. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. See drawing schedule for field-applied jacket material specifications

C. Self-Adhesive Indoor/Outdoor Jacket: Matt White, 40 or 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following

    a. Venture Cadd, FlexClad-400 is a 40 mil.
    b. Polyguard Products, Inc.; Alumaguard® Lite Cool Wrap™.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABI, Ideal Tape Division; 428 AWF ASJ.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    c. Compac Corporation; 104 and 105.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABI, Ideal Tape Division; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Compac Corporation; 110 and 111.
    d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABI, Ideal Tape Division; 370 White PVC tape.
    b. Compac Corporation; 130.
    c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or; 0.015 inch thick, 1/2 inch wide with wing seal
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
4. 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, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; CHP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.

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. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. 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. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030-inch-thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

2.10 CORNER ANGLES

A. Stainless-Steel Corner Angles: 0.024 inch-thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 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 more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. Exposed Ductwork: Locate insulation and cover seams in least visible locations.

P. All duct insulation shall be continuous through walls, ceiling or floor openings and through sleeves except where firestop or firesafing materials are required. Vapor retarding jacket shall be maintained continuous through all penetrations.

Q. 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.

R. Provide a complete vapor retarding jacket for insulation on the following systems:

1. Insulated Duct.
2. Ductwork with a surface temperature below 65 degrees F.

S. Duct silencers for insulated supply ductwork shall be insulated on all four sides similar with materials.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches 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 078413 "Penetration Firestopping" and fire-resistive joint sealers.

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not over compress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not over compress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where Self-Adhesive Interior/Outdoor Jacket are indicated, install per manufacturer’s guidelines. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

1. Provide a protective covering of self-adhering jacket (SAJ) meeting 25/50 Flame Spread/Smoke Rating for the following ductwork:

a. Interior insulated ductwork within 10’ of floor, catwalks and mezzanines areas.

B. 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 with plastic squeegee for full adhesion and sealing at joint overlaps. On exterior applications, provide a bead of compatible caulk along exposed edges.

C. Piping with self-adhering (SAJ) jackets shall have butt joints wrapped with 2 layers of vapor retarding tape. Vapor retarding tape shall be compatible with the jacket material used.

3.7 FINISHES

A. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

B. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Engineer.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation: See Drawing Schedule.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

1. Refer to Schedule on Drawings.

3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

1. Refer to Schedule on Drawings.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. See drawing schedule for items requiring indoor field-applied jacketing.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. See drawing schedule for items requiring outdoor field-applied jacketing.

3.14 FIELD QUALITY CONTROL

A. Any discovered deviation from the specified materials and methods shall be considered cause for spot-check dismantling of Work to be performed during the preceding day's work. If further deviations are so discovered, the day's Work proceeding that day may be requested to be checked. All dismantling and reinstallation shall be performed at no additional cost to the Contract.

END OF SECTION 23 07 13

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "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.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "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 in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. See drawing schedule(s) for insulation material specifications

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Aeroflex USA, Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Fibrex Insulations Inc.; Coreplus 1200.
    b. Johns Manville; Micro-Lok.
    c. Knauf Insulation; 1000-Degree Pipe Insulation.
    d. Manson Insulation Inc.; Alley-K.
    e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ or with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Armacell LLC; Tubolit.
b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Ramco Insulation, Inc.; Super-Stik.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Aeroflex USA, Inc.; Aeroseal.
b. Armacell LLC; Armaflex 520 Adhesive.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.

b. - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
    b. - Marathon Industries; 501.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
    d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
    b. - Marathon Industries; 570.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
    b. - Marathon Industries; 550.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
    d. Mon-Eco Industries, Inc.; 55-50.
    e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
    b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.

c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

1. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

B. See drawing schedule for field-applied jacket material specifications

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABI, Ideal Tape Division; 428 AWF ASJ.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    c. Compac Corporation; 104 and 105.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABI, Ideal Tape Division; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Compac Corporation; 110 and 111.
    d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABI, Ideal Tape Division; 370 White PVC tape.
    b. Compac Corporation; 130.
    c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.

3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015-inch-thick, 1/2-inch-wide with wing seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 1/2 inch wide with wing sea.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches 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 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.
7. Unions
8. Flanges
9. Strainers
10. Valves

Q. In systems with rigid insulation, slip joints shall be installed every 25-30 feet for thermal expansion. They shall overlap and be caulked according to the jacket manufacturer's installation recommendation. On cold piping, flexible fiberglass insulation shall separate the rigid insulation pieces at the slip joint

3.4 PENETRATIONS

A. Insulation Installation at 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: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded

with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches 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.

E. When insulating control valves, strainers, and any other devices requiring frequent access, the insulation shall be fit in such a way that there is an access section which can be readily removed and replaced without damaging adjacent insulation. If a different insulating material is used for boxing in control valve assemblies, etc., the thickness of the insulation shall be adjusted to provide the specified thermal resistance.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. 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.
2. Provide a protective covering of PVC jacket meeting 25/50 Flame Spread/Smoke Rating for the following ductwork:

a. Interior insulated piping within 8’ of floor, catwalks and mezzanines areas.

C. 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.

3.9 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two

locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

C. See drawings schedule for pipes requiring insulation

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. See drawing schedule for items requiring outdoor insulation.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. See drawing schedule for items requiring indoor field-applied jacketing.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. See drawing schedule for items requiring outdoor field-applied jacketing.

3.15 FIELD QUALITY CONTROL

A. Any discovered deviation from the specified materials and methods shall be considered cause for spot-check dismantling of Work to be performed during the preceding day's work. If further deviations are so discovered, the day's Work proceeding that day may be requested to be checked. All dismantling and reinstallation shall be performed at no additional cost to the Contract.

END OF SECTION 23 07 19

SECTION 23 08 00

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.5 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.7 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work; provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Contractor and their subcontractors, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in HVAC boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls." Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

F. Vibration Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation controls.

END OF SECTION 23 08 00

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Section 230519 "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
2. Section 230924 "Direct Digital Control System for HVAC" for requirements that relate to this Section.
3. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

C. Furnish and install all labor, materials, equipment, electronic interfaces and actuation devices, apparatus, software, services, permits and supervision, and all permanent and temporary facilities necessary to provide complete and proper working Direct Digital Control system as indicated on the drawings, called for in the specifications or required by job conditions. Drawings are diagrammatic only. Provide any equipment and labor not specifically referred to herein or on the drawings that are required to meet the functional intent, such as repeaters, routers, bridges, and gateways.

1.3 SYSTEM DESCRIPTION

A. System is to use direct digital control with electric actuation for air handling units; direct digital control with electric actuation for room temperature, room humidity, and terminal airflow control; and electric control for other terminal units.

1.4 DEFINITIONS

A. BAS: Building Automation System.

B. DDC: Direct digital control.

C. I/O: Input/output.

D. LAN: Local Area Network.

E. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

F. RTD: Resistance temperature detector.

1.5 SYSTEM PERFORMANCE

1. Comply with the following performance requirements:

2. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

    a. Water Temperature: Plus or minus 1 deg F.
    b. Water Flow: Plus or minus 5 percent of full scale.
    c. Water Pressure: Plus or minus 2 percent of full scale.
    d. Space Temperature: Plus or minus 1 deg F.
    e. Ducted Air Temperature: Plus or minus 1 deg F.
    f. Outside Air Temperature: Plus or minus 2 deg F.
    g. Dew Point Temperature: Plus or minus 3 deg F.
    h. Temperature Differential: Plus or minus 0.25 deg F.
    i. Relative Humidity: Plus or minus 5 percent.
    j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
    k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
    l. Airflow (Terminal): Plus or minus 10 percent of full scale.
    m. Air Pressure (Space): Plus or minus 0.01-inch wg.
    n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
    o. Carbon Monoxide: Plus or minus 5 percent of reading.
    p. Carbon Dioxide: Plus or minus 50 ppm.
    q. Electrical: Plus or minus 5 percent of reading.

B. Communications protocol:

1. BACnet protocol per the latest version of ASHRAE Standard 135 and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
2. LonTalk protocol using the LonWorks neuron chip from Echelon Corporation and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

C. Engineering units: English.

D. Provide at least 10% spare I/O connections on each controller.

E. Components shall operate within 32 deg F to 122 deg F and 5-85% relative humidity, non-condensing.

1.6 SEQUENCE OF OPERATION

A. Refer to Section 230925 "Direct Digital Control System for HVAC" for requirements that relate to this Section.

1.7 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams for each system showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring. Differentiate between factory and field installed wiring.
4. Wire Tabulation List: wire ID, "to" and "from", and wire color.
5. Details of control panel faces, including controls, instruments, and labeling.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. Control valve assemblies shall be provided and delivered from a single manufacturer as a complete assembly.

C. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.

D. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

1.8 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.

C. Qualification Data: For Installer.

D. Field quality-control test reports.

1.9 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.
5. Programming manuals.
6. Maintenance instructions.
7. Record documents (“as-builts”), including updated schematic diagrams, wiring diagrams, and control sequences.
8. Training documentation.
9. Contact information of service contractor and parts suppliers.

1.10 QUALITY ASSURANCE

A. Installing contractor must be a manufacturer's branch office or an authorized representative of a Direct Digital Control (DDC) equipment manufacturer that provides engineering and commissioning of the DDC equipment. Submit written confirmation of such authorization from the manufacturer. Indicate in letter of authorization that installing contractor has successfully completed all necessary training required for engineering, installation, and commissioning of equipment and systems and that such authorization has been in effect for a period of not less than three years. DDC equipment may or may not be required to be installed by this contractor as part of the project, but the intent of this quality assurance specification is to ensure that the installing contractor has the capabilities to engineer, install, and commission the field devices supplied under this section for temperature control.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE 135 for DDC system components.

D. Comply with the following:

1. UL-916; Energy Management Systems.
2. UL-873; Temperature Indication and Regulating Equipment.
3. UL-864, Subcategories UUKL, UOXX, UDTZ; Fire Signaling and Smoke Control Systems.
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

1.12 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

1.13 WARRANTY

A. Provide warranty on all parts and labor for one year starting at the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

1. Refer to Section 230924 "Direct Digital Control System for HVAC" for requirements that relate to this Section.

2.3 INTERFACE WITH DDC EQUIPMENT

A. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers. Systems which command multiple outputs over a single pair of wires, such as power line carrier systems, are not acceptable.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.
8. SPDT Output Relays: Indicate status with an LED.

B. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
4. Provide all required power supplies for transducers, sensors, transmitters and relays. All low voltage transformers shall have a resettable secondary circuit break.

C. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

D. Control Panels:

1. Provide panel enclosures for all DDC controllers and associated function modules. All controls to be in enclosures without exception. Panels will be approved provided all conduit is bonded and grounded.
2. Provide UL listed cabinets for use with line voltage devices.
3. See Division 26 for control panel assembly and installation.
4. NEMA Rating:
    a. Inside: NEMA-1.
    b. Outside: NEMA-3R or NEMA-4.
5. Constructed of steel or extruded aluminum, with hinged door, keyed lock, and baked enamel finish. Install controls, relays, transducers and automatic switches inside panels. Label devices with permanent printed labels and provide asbuilt wiring/piping diagram within enclosure. Provide raceways for wiring and poly within panel for neat appearance. Provide termination blocks for all wiring terminations. Label outside of panel with panel number corresponding to plan tags and asbuilt control drawings as well as building system(s) served.
6. Control panels that have devices or terminations that are fed or switch 50V or higher shall enclose the devices, terminations, and wiring so that Personal Protective Equipment (PPE) is not required to service the under 50V devices and terminations within the control panel. As an alternative, a separate panel for only the 50V and higher devices may be provided and mounted adjacent to the under 50V control panel.
7. For panels that have 120VAC power feeds provide a resettable circuit breaker. Provide label within the panel indicating circuit number of 120VAC serving panel
8. Provide a service shutdown toggle switch for each air handling unit system located inside the temperature control panel that will initiate a logical shutdown of the air handling unit system. Label the switch so it is clear which position is shutdown and which is auto.

E. Interface with Other Systems: All hardware and software required to provide the specified interactions with other systems, such as fire alarm, security, and lighting systems.

2.4 ELECTRONIC SENSORS AND TRANSMITTERS

A. General Requirements:

1. Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. For wall, immersion, or duct mounting as required.
    a. Architectural housing for office space mounting.

b. Weatherproof/sunshield housing for outdoors.
c. Thermowell housing for water applications.

1) Non-corrosive fluids below 250 deg F: brass or stainless steel.
2) Other applications: 300 series stainless steel.

d. Protective housing for duct mounting.
e. Water and dust tight stainless-steel housing for space sensors located in process areas.

3. The sensor/transducer shall be selected to withstand ambient conditions, including moisture or condensation and transient conditions for temperatures, pressures, humidities, etc.
4. Transducers may be supplied as an integral unit with the field sensor, or as part of the controller.
5. The sensor/transducer shall be appropriately selected to most closely match the expected sensing range.
6. Use a transmitter where the sensor is more than 100 feet from its associated controller, there is excessive electrical noise present, or the controller cannot accept direct sensor input, a 4-20mA type.
7. All temperature and humidity sensors shall be of the same manufacturer.
8. All pressure transmitters and transducers shall be of the same manufacturer.

B. RTDs and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.
b. MAMAC Systems, Inc.
c. RDF Corporation.

2. Accuracy: Plus or minus 0.2 percent at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
5. Averaging Elements in Ducts: 18 inches long, rigid use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Concealed.
b. Set-Point Indication: Concealed.
c. Thermometer: Concealed.
d. Color: White.
e. Orientation: Vertical.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:

a. BEC Controls Corporation.
b. General Eastern Instruments.
c. MAMAC Systems, Inc.
d. ROTRONIC Instrument Corp.
e. TCS/Basys Controls.
f. Vaisala.

2. Accuracy: 2 percent full range with linear output.
3. Room Sensor Range: 20 to 80 percent relative humidity.

4. Temperature Effect: 0.06 percent per deg F.
5. Repeatability: 0.5 percent relative humidity.
6. Hysteresis: 1 percent.
7. Long-term Stability: 1 percent relative humidity drift per year.
8. Room Sensor Cover Construction: Manufacturer's standard locking covers.

    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Concealed.
    c. Thermometer: Concealed.
    d. Color: White.
    e. Orientation: Vertical.

9. Duct Sensor: 0 to 95 percent relative humidity range with element guard and mounting plate.
10. Outside-Air Sensor: 0 to 95 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F]
11. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

D. Pressure Transmitters/Transducers:

1. Manufacturers:

    a. BEC Controls Corporation.
    b. General Eastern Instruments.
    c. MAMAC Systems, Inc.
    d. ROTRONIC Instrument Corp.
    e. TCS/Basys Controls.
    f. Vaisala.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

    a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
    b. Output: 4 to 20 mA.
    c. Building Static-Pressure Range: 0- to 0.25-inch wg.
    d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
7. Air Filters: Provide filters on all pressure probes in return or exhaust air systems.

E. PRESSURE TRANSDUCERS (AIR)

1. Provide pressure transducers specified below for the following applications:

    a. Duct static pressure applications where setpoints are specified to control at greater than 0.1” w.c.
    b. Pitot type fan inlet air flow stations.

2. Manufacturers: Mamac Systems, Setra, and Veris Industries.
3. Provide a transmitter that operates on the capacitance principle and is capable of sensing low positive, negative or differential pressures. Transmitter shall have a minimum of three pressure ranges adjustable by an onboard switch or jumper. Size the transmitter where the middle or high range is suitable for the

application. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.

a.	Accuracy (including non-linearity and hysteresis)	+ 1% FS
b.	Compensated Temperature Range	32°-140° F
c.	Temperature Effect	0-1"wc Range .09% FS/°F;
d.		>1"wc Range .02% FS/°F
e.	Output	4-20 MA
f.	Load Impedance (smallest maximum acceptable)	800 Ω max.
g.	Operating Temperature	32°-140° F

4. Provide pressure transducers specified below for the following applications:

   a. Duct static pressure applications where setpoints are specified to control at 0.1" w.c. or lower.
   b. All duct mounted pitot type air flow stations.
   c. Space/building static control or monitoring.

5. Manufacturers: Paragon Controls MicroTrans, Air Monitor Veltron DPT2500 Plus, or approved equal.
6. The airflow transducer shall provide noise filtration and automatic auto-zeroing. The automatic zeroing circuit shall be capable of maintaining the transducer output to within ±0.25% of operating span. The transducer output shall be locked and maintained at the last given output value during the automatic zeroing period so as not to interrupt the automatic control process. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.
7. Transducer Span: <2 times the design velocity pressure at maximum flow, single range
8. Accuracy: ±0.25% of full scale, including non-linearity, hysteresis, deadband, and non-repeatability
9. Temperature Effect: ±0.15% of full scale/°F
10. Response: 0.5 sec. for 98% of full span change
11. Overpressure: 5 PSIG Proof
12. Power: 24VAC/VDC
13. Analog Output: 0-5VDC, 0-10VDC, or 4-20mA field adjustable
14. Auto Zero Frequency: every 1 to 24 hours on 1 hour intervals
15. For space or building static pressure monitoring, use Vaisala model SPH10 Static Pressure Head, or approved equal for outside air reference. Mount in location shown on plans or approved by AE.

F. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Concealed.
2. Set-Point Indication: Concealed.
3. Thermometer: Concealed.
4. Color: White
5. Orientation: Vertical.

G. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.
2. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.
3. Adjusting Key: As required for calibration and cover screws.

2.5 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements. Provide a current sensor with adjustable threshold and digital output with LED display, equal to a Veris model H-708/H-904. Threshold adjustment must be by a multi-turn potentiometer or set by multiprocessor that will automatically compensate for frequency and amperage changes associated with variable frequency drives. When used on variable speed motor applications, use a current sensor that will not change state due to varying speeds.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure NTP fitting, rated for 300 psig for chilled water applications or 150 psig other applications.

1. Manufacturers:

   a. BEC Controls Corporation.
   b. I.T.M. Instruments Inc.

I. Position Sensors:

1. Rotary Switches: cam action, lever, or proximity type, accuracy plus or minus 1 percent of full span, repeatability plus or minus 0.5 percent of full span, maximum temperature 125 deg F.
2. Door Position Switches: magnetic proximity type.

J. Paddle Flow Switches: Adjustable setpoint, selected for accuracy and ranges to match process conditions and electrical requirements; mounted on duct top, side, or bottom. Mounting in vertical duct with downward flow is not allowed.

2.6 GAS DETECTION EQUIPMENT

A. Standalone Carbon Monoxide and Nitrogen Dioxide Detectors and Controllers

1. Available Manufacturers:

   a. B. W. Technologies.
   b. CEA Instruments.
   c. Vulcain Inc.

2. Controller:

   a. General: Microprocessor controlled, capable of performing the specified sequence of operation.
   b. Enclosure: Corrosion resistant.
   c. Operating Temperature Range: 32 to 104 deg F.
   d. Operating Relative Humidity Range: 15 to 90%, non-condensing.
   e. Input Power: 120V connection. 24V with transformer is acceptable.
   f. Outputs:

1) Indicating Lights: For power and alarm.
2) Audible Alarm: with manual silence switch.
3) Ventilation Equipment Activation Relay: 120V, 5A at 240 VAC.
4) Fault Alarm Relay: 24V, to signal building automation system.
5) Activate ventilation equipment when power to controller fails.

g. Accessories:

1) Calibration kit.
2) Splash Protection: Corrosion-resistant splash guard with transparent cover to see indicating lights, or NEMA rating 3R or higher.

3. Sensors:

a. General: Electrochemical, factory calibrated.
b. Accuracy: +5%.
c. Minimum Life: 2 years
d. Repeatability: +10% at calibration point.

4. Alternates:

a. A separate controller with remote transmitters is permitted.
b. Combination carbon dioxide / nitrogen dioxide sensors or transmitters are permitted.

B. Manufacturers:

1. B. W. Technologies.
2. CEA Instruments, Inc.
3. Ebtron, Inc.
4. Gems Sensors Inc.
5. Greystone Energy Systems Inc.
6. Honeywell International Inc.; Home & Building Control.
7. INTEC Controls, Inc.
8. I.T.M. Instruments Inc.
9. MSA Canada Inc.
10. QEL/Quatrosense Environmental Limited.
11. Sauter Controls Corporation.
12. Sensidyne, Inc.
13. TSI Incorporated.
14. Vaisala.
15. Vulcain Inc.
16. Brasch Manufacturing Company.
17. General Analysis Corporation.
18. Macurco Inc.
19. MDA Scientific
20. Toxalert.

C. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F; with 2 factory-calibrated alarm levels at 35 and 200 ppm in a heavy-gauge aluminum NEMA 1 enclosure.

D. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; range 0 to 2000 ppm, self-calibrating, for wall mounting.

E. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

F. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

G. Nitrogen Dioxide Detection System: packaged system with microcontroller, sensor(s), control relays and contacts in a heavy-gauge aluminum NEMA 1 enclosure.

1. Detection Resolution: Plus or minus 0.1 ppm.
2. Ambient Temperature Range: Minus 4 to plus 113 deg F (minus 20 to 45 deg C).
3. Ambient Humidity Range: 10 to 95 percent relative humidity.
4. Low alert level adjustable in increments of 0.1 ppm.
5. Indicator lights for power, relay status, and alarm condition.
6. Protected against static discharge, excessive electrical noise, and tested in accordance with ANSI/UL 1244.
7. Output relays providing a normally closed set of contacts for the alert states and the alarm states, which will automatically operate ventilation equipment on power loss to the sensor.
8. If a large area must be monitored with multiple sensors, a controller system with remote sensors may be used.

2.7 CARBON DIOXIDE (CO2) SENSOR

A. Provide a Carbon Dioxide (CO2) sensor that shall utilize non-dispersive infrared (NDIR) technology. The sensor shall have a linear analog output over a range of 0-2000 ppm and have built in display of CO2 level. The sensor shall have an automatic calibration algorithm that will compensate for sensor drift over time due to sensor element degradation. Unit shall be provided with a 0-10VDC or 4-20mA analog output that is selectable and a field adjustable relay alarm output. Accuracy shall be better than ±5% of reading or ±50ppm whichever is higher. The sensor shall be user calibratable with a minimum calibration interval of five years.

2.8 FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.

1. Manufacturers:

a. Ebtron.
b. Tek-Air.
c. Air Monitor.
d. Kurz Instruments.

2. Casing: Galvanized-steel frame, same size as duct.
3. Flow Straightener: Aluminum honeycomb, 3/4-inch parallel cell, 3 inches deep.
4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.
5. Accuracy: 2 percent of full range.

B. Provide duct mounted airflow station type based on the following manufacturer's minimum design velocities. Outside air flow stations shall be thermal dispersion type only. Turndown of variable volume fan systems must be considered. Provide an airflow station schedule detailing the airflow range to be measured, corresponding velocity pressure, differential pressure transducer range, and the airflow station size.

C. Fan inlet piezometers: Where fan inlet piezometers are provided, these shall be used by the control contractor for air flow measurement. The air velocity transducers shall be provided under this Section and sized as described below.

D. For factory mounted fan piezometers rings, air velocity transducers range shall be sized less than two times the design velocity pressure at maximum flow and will meet the requirements under the PRESSURE TRANSDUCERS (AIR) specification later in this specification section unless noted below.

E. Thermal dispersion air flow stations:

1. Probe Sensor Density:

	Area (sq. ft.)	Sensors
a.	<= 1.5	2
b.	>1.5 to <4	4
c.	4 to <8	6
d.	8 to <12	8
e.	12 to <16	12
f.	>=16	15

2. Airflow Sensor Accuracy: ±2% of reading
3. Calibrated Range: 0-2500 FPM for duct applications and 5000 FPM for fan inlet applications
4. Temperature Sensor Accuracy: ±0.15°F
5. Temperature: -20°F to +140°F
6. Relative Humidity: 0 to 95% (non-condensing)

F. Provide transmitter that will average up to sixteen sensors and provide two field selectable linear analog output signals (4-20mA and 0-10 VDC) proportional to airflow and temperature. Sensor electronic circuitry other than the temperature sensors shall not be exposed to the air stream and shall be protected from moisture to prevent failure.

2.9 THERMOSTATS

A. Manufacturer: Basis-of-Design Product: The design is based on the following:

1. Honeywell TR71.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Erie Controls.
2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
3. Heat-Timer Corporation.
4. Sauter Controls Corporation.
5. Tekmar Control Systems, Inc.
6. Theben AG - Lumilite Control Technology, Inc.

C. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF" or "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF" based on system operation.
2. Mount on single electric switch box.

D. Electric, solid-state, microcomputer-based room thermostat with remote sensor and occupancy modes. (Type T1)

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set up for four separate temperatures per day.
4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
5. Three-hour occupied override button.
6. Short-cycle protection.
7. Programming based on weekday, Saturday, and Sunday.

8. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, fan on-auto, and occupied/unoccupied modes.
9. Battery replacement without program loss.
10. Minimum deadband temperature: 2 deg F.
11. Control accuracy: +1 deg F.
12. Multiple stage operation as required by equipment being controlled.
13. Thermostat display features include the following:

    a. Time of day.
    b. Actual room temperature.
    c. Programmed temperature.
    d. Programmed time.
    e. Duration of timed override.
    f. Day of week.
    g. System mode indications include "heating," “cooling,” "off," "fan auto," "fan on", “occupied,” and “unoccupied.”

E. Electric, solid-state, microcomputer-based room thermostat with remote sensor (Type T2).

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set up for four separate temperatures per day.
4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
5. Short-cycle protection.
6. Programming based on weekday, Saturday, and Sunday.
7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
8. Battery replacement without program loss.
9. Minimum deadband temperature: 2 deg F.
10. Control accuracy: +1 deg F.
11. Multiple stage operation as required by equipment being controlled.
12. Thermostat display features include the following:

    a. Time of day.
    b. Actual room temperature.
    c. Programmed temperature.
    d. Programmed time.
    e. Duration of timed override.
    f. Day of week.
    g. System mode indications include "heating," “cooling,” "off," "fan auto," and "fan on."

F. Low-Voltage, On-Off Thermostats (Type T3): NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, visible temperature reading, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

G. Line-Voltage, On-Off Thermostats (Type T4): Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; visible temperature reading, listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

H. Remote-Bulb Thermostats (Type T5): On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.

3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

I. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 1 foot (3 m) for every square foot of coil surface.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

J. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
3. Temperature Setpoint: 38 deg F, adjustable within 35 deg F to 45 deg F.

K. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig and cast housing with position indicator and adjusting knob.

L. Hazardous Room Thermostats (Type T13): Equal to Johnson Controls A19BUC-2, line voltage, SPDT, single stage, external adjustment knob, external sensing coil secured to enclosure, and temperature sensing range 20 deg F to 80 deg F; for Class I or II, Group D, E, F, or G locations.

M. Thermostat Accessories:

1. Cover: Manufacturer's standard locking covers.
2. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base
3. Insulating Bases: For sensors located on exterior walls.

2.10 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action. Stroke time for 90-degree rotation 90 seconds or less for major equipment and 6 minutes or less for terminal equipment. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops. Provide pilot positioners.

1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
7. Provide external adjustable stops on damper actuators.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque. Stroke time for 90-degree rotation 90 seconds or less for major equipment and 6 minutes or less for terminal equipment. Provide

position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops. Provide pilot positioners.

1. Manufacturers:

    a. Belimo Air Controls (USA), Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure. Provide operators and pilot positioners with linkages and brackets for mounting on control valve. Design mounting and/or support to provide no more than 5% hysteresis in either direction.
3. Dampers: Size for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
    e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: 40 to 104 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Run Time: 12 seconds open, 5 seconds closed.
13. Provide external adjustable stops on damper actuators.
14. Position Feedback:

    a. Two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
    b. Modulating actuators with a position feedback through current or voltage signal for remote monitoring. Add a 500 ohm resistor across a 4-20 mA signal to create a 2-10 VDC signal when required.
    c. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
    d. Provide auxiliary switches and feedback potentiometer for control valves and damper actuators for position indication. Belimo actuators and auxiliary switches are designed for IEC protection class II and double insulated.

2.11 CONTROL VALVES

A. Manufacturer: Basis-of-Design Product: The design is based on the following:

1. Belimo Air Controls (USA), Inc.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Honeywell
2. Siemens
3. Johnson Controls, Inc.

C. Hydronic system control valves shall have the following characteristics:

1. NPS 2 and Smaller:

a. Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
b. Characterized Ball Valves: The following manufacturers are acceptable: Belimo, Air Controls (USA), and Johnson Controls. Forged brass or bronze body, stainless steel shaft and ball, reinforced Teflon or PTFE ball seals, double O-ring stem seals, characterized disk, maximum of ANSI Class IV (0.01%) leakage, suitable for use on water systems at 150 psig and 212° F. Minimum size for ball valves shall be 0.4 Cv.

1) Pressure Rating for NPS 1 and Smaller: Nominal 600 psi.
2) Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 psi.
3) Close-off Pressure: 200 psig.
4) Process Temperature Range: Zero to 250 deg F.
5) Control Port Leakage: 0%
6) Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
7) End Connections: Threaded (NPT) ends.
8) Ball: stainless steel.
9) Stem and Stem Extension:
10) Material to match ball.
11) Blowout-proof design.
12) Ball Seats: Reinforced PTFE.
13) Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
14) Flow Characteristic: Equal percentage.

2. NPS 2-1/2 and Larger: Class 125 iron, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:

a. Two Position: Line size.
b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer or Lug.
2. Disc Type: Nickel-plated ductile iron or Elastomer-coated ductile iron.

3. Sizing: 1-psig maximum pressure drop at design flow rate.
4. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

E. Terminal Unit Control Valves: Pressure Independent Control valve (PICV) Bronze body, bronze trim, two or three ports ball valve as indicated, replaceable plugs and seats, and union and threaded ends.

1. PICV equal to Belimo Zone Tight ball valve (PIQCV)
2. Combination of differential pressure regulator and 2-way valve.
3. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
4. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Performance:

    a. Pressure Rating: 360 psig.
    b. Close-off pressure of 200 psig.
    c. Process Temperature Range: Between 36 deg F to 212 deg F.
    d. Rangeability: 100 to 1.

7. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
8. Body: Forged brass, nickel plated, and with threaded ends.
9. Ball: Stainless steel.
10. Stem and Stem Extension: Stainless steel, blowout-proof design.
11. Ball Seats: Reinforced PTFE.
12. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.

F. All valves unless specifically noted on the plans or indicated below shall be globe style or Characterized Ball valves.

VALVE SERVING	**TYPE** Globe Butterfly (BF) Ball Press Independent Ball (PI Ball)	**SIGNAL** 0-10 VDC 2-Position Elect	**SPRING RETURN** REQUIRED Yes No	**FAIL POSITION** Open (thru Coil) Closed (bypass Coil) Last Position
Booster Reheat Coil	PICV Ball	0-10 VDC	No	Last Position
Radiation w/Reheat	PICV Ball	0-10 VDC	No	Last Position
Standalone Radiation	PICV Ball	0-10 VDC	No	Last Position
Radiant Manifolds	PICV Ball	0-10 VDC	No	Last Position
Unit Heaters	PICV Ball	2-Pos Elect	Yes	Open
MAU Heating Coil	Globe	0-10 VDC	Yes	Open
AHU Heating Coil	Globe	0-10 VDC	Yes	Open

2.12 DAMPERS

A. Manufacturer: Basis-of-Design Product: The design is based on the following:

1. TAMCO 7000 (T. A. Morrison & Co. Inc.).

B. Manufacturers:

1. Air Balance Inc.
2. Don Park Inc.; Autodamp Div.
3. United Enertech Corp.
4. Vent Products Company, Inc.

C. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch-minimum thick, galvanized-steel or 0.125-inch-minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch-thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch-diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze or nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

D. High-Performance Control Dampers: AMCA-rated.

1. Frame: extruded-aluminum, 0.125-inch-minimum thick; frames with holes for duct mounting.
2. Blades: minimum 0.064-inch-thick aluminum with maximum blade width of 8 inches and length of 48 inches, with end caps.
3. Secure blades to 1/2-inch-diameter, zinc-plated axles using zinc-plated hardware, with Celcon inner bearing fixed to an aluminum hexagon blade pin rotating within a polycarbonate outer bearing inserted in the damper frame, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
4. Operating Temperature Range: From minus 40 to plus 200 deg F
5. Edge Seals: Use inflatable blade edging or replaceable silicone rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 1.7 cfm per sq. ft. of damper area, at differential pressure of 1-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.13 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 100 VA.
3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:

1. General Power-Line Conditioner Requirements:

a. Design to ensure maximum reliability, serviceability and performance.

b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

2. Standards: NRTL listed per UL 1012.
3. Performance:

a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h. Attenuate load-generated odd current harmonics 23 dB at the input.
i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
k. Common-mode noise attenuation of 140 dB.
l. Transverse-mode noise attenuation of 120 dB.
m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
n. Reliability of 200,000 hours' MTBF.
o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
p. Approximately 92 percent efficient at full load.

4. Transformer Construction:

a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.

g. Include interface terminals for output power hot, neutral and ground conductors.
h. Label leads, wires and terminals to correspond with circuit wiring diagram.
i. Vacuum impregnate transformer with epoxy resin.

C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

1. The maximum continuous operating voltage shall be at least 125 percent.
2. The operating frequency range shall be 47 to 63 Hz.
3. Protection modes according to NEMA LS-1.
4. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:

a. Line to Neutral: 45,000 A.
b. Neutral to Ground: 45,000 A.
c. Line to Ground: 45,000 A.
d. Per Phase: 90,000 A.

5. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:

a. Line to Neutral: 360 V.
b. Line to Ground: 360 V.
c. Neutral to Ground: 360 V.

6. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.

a. Line to Neutral:

1) 100 kHz: 42 dB.
2) 1 MHz: 25 dB.
3) 10 MHz: 21 dB.
4) 100 MHz: 36 dB.

b. Line to Ground:

1) 100 kHz: 16 dB.
2) 1 MHz: 55 dB.
3) 10 MHz: 81 dB.
4) 100 MHz: 80 dB.

7. Unit shall have LED status indicator that extinguishes to indicate a failure.
8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
9. Unit shall not generate any appreciable magnetic field.
10. Unit shall not generate an audible noise.

D. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

a. Output voltage nominally 25-V dc within 5 percent.
b. Output current up to 100 mA.
c. Input voltage nominally 120-V ac, 60 Hz.
d. Load regulation within 0.5 percent from zero- to 100-mA load.
e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.14 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling."

2.15 ANALOG ELECTRONIC INSTRUMENT INDICATORS

A. Panel mount type and at least 2" square.

B. Output: analog needle type or digital with ½" high LED or backlit LCD displays.

C. Marked in appropriate units (Degrees, PSI, %RH, GPM, CFM, etc.) and with appropriate range of values.

D. Minimum accuracy of 1% of scale range.

E. Digital units shall be scaled to show 3 digits plus 1 decimal point.

2.16 SWITCHES

A. Emergency Shutdown Pushbutton: Wall-mounted, mushroom-type momentary (reset through building automation system) pushbutton, pilot light or pushbutton illuminated after activation, NEMA 1, clear lifting cover, stainless steel cover plate, labeled “EMERGENCY VENTILATION STOP” or similar wording.

1. Available Manufacturers: Kele ST120SL.

B. Boiler Kill Switch: Kele WPS-MP-BS-CLM with auxiliary contacts Kele PILNCCB or equal. Switch shall be a push-pull maintained contact switch with clear hinged lockout lid and auxiliary contacts for DDC monitoring and each boiler. Labeling shall be provided to indicate switch is for Emergency Boiler Shut-Down and action required to reset.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 SYSTEM DESIGN

A. General Criteria:

1. Size all control devices to properly supply and/or operate and control the apparatus served.
2. Provide control devices suitable for the environment in which they will operate:

a. All devices shall be constructed to withstand system temperatures and pressures.
b. Devices used in outdoor ambient conditions shall be constructed to withstand those conditions or shall be suitably weather protected.

c. Devices in corrosive environments shall be constructed of materials to withstand the effects of that environment.

B. Control Dampers:

1. General:

a. Unless otherwise indicated, use opposed blade for modulating control dampers and use parallel blade dampers for two position (open/close) dampers and for mixing applications.
b. All blade linkage hardware shall have a corrosion resistant finish and be readily accessible for maintenance.
c. Damper construction material shall be the same as the connecting duct material. Exception: Aluminum damper may be used in a galvanized duct system.
d. Maximum single damper size shall be 48"x48". If total width or height exceeds maximum, use multiple dampers.
e. Locate actuators outside of the air stream, unless otherwise indicated.

2. Sizing/selection criteria:

a. Two position dampers shall be sized as close as possible to duct size but in no case is the damper to be less than duct area.
b. When damper is part of an intake louver assembly, damper shall be same nominal size as louver unless specified otherwise on drawings.
c. All dampers used for mixing of airstreams shall be sized for 1800 to 2000 feet per minute velocity.

3. All control dampers furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control
4. Damper end switches, where required, shall be independently mounted to the damper drive shaft or auxiliary shaft attached to a damper drive blade. End switches shall be adjusted to prove the damper the position opposite the fail position of the damper actuator unless the control sequence requires a different position to be proven to accomplish the specified control sequence.
5. Coordinate installation with the sheetmetal installer to obtain smooth duct transitions where damper size is different than duct size. Blank off plates will not be accepted.
6. Each operator shall serve a maximum damper area of 36 square feet. Where larger dampers are used, provide multiple operators.

C. Control Valves:

1. All temperature control valves furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control.
2. Sizing/selection criteria:

a. Valves with pressure drop greater than 50% of upstream pressure shall have sound reduction trim.
b. Water Service:

1) Characteristic: equal percentage for two-way valves; linear for three-way valves.
2) Select control valves based on pressure drop calculations based on C_v values at 100% stroke.
3) Heating: globe type, selected for a minimum of 25% of equipment subcircuit pressure drop but no more than maximum available pump head allowing 2 psi pressure drop for balancing valve.
4) Cooling: globe or butterfly type, selected for minimum of 10% of equipment subcircuit pressure drop, but not more than maximum pump head allowing minimum 2 psi

pressure drop for balancing valve. Modulating butterfly valves shall be high performance type.

D. Air Temperature Sensors:

1. Ducts with cross-sectional area less than 3 square feet: single point type.
2. Ducts with cross-sectional area more than 3 square feet: RTD type.
3. Mixed air: averaging type

3.3 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

1. Check and verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Align with light switches and humidistats. For drywall installations, thermostat mounting shall use a back-box attached to a wall stud, drywall anchors are not acceptable.

C. Verify location of thermostats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
2. Meet ADA requirements.
3. Locate temperature sensors away from direct sunlight, diffuser air streams, and heat sources.
4. Install thermostats and temperature sensors mounted on outside walls on insulated subbases. Subbase to provide a minimum of one half inch of insulation.
5. Install devices with visible readouts where the display can be easily read.

D. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.
4. Provide guards on thermostats and sensors in entrance hallways, other public areas, or in locations where thermostat is subject to physical damage.

E. Install automatic dampers according to Section 233300 "Air Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."

H. Install hydronic instrument wells, valves, and other accessories according to Section 232116 Hydronic Piping Specialties."

I. Install refrigerant instrument wells, valves, and other accessories according to Section 232300 "Refrigerant Piping."

J. Install electronic and fiber-optic cables according to Section 271000 "Communications Cabling."

K. Provide power wiring to each component requiring power, such as control panels. Use circuits dedicated for controls. For equipment on emergency power, use emergency power circuits for their controllers.

L. Mount all control devices in accessible locations.

M. Interposing Relays:

1. Provide interposing relays necessary for interfacing to low voltage outputs with 120 VAC or line voltage motor control.

   a. Use Type C horsepower rated interposing relays for motors and electric heaters.
   b. Use Type K interposing relays for other general-purpose use.

N. Well-Mounted Sensors:

1. Install thermal conducting compound.
2. In pipe 2 ½ inches and smaller: install at elbow with tee fitting with well pointed upstream. Minimum 2” tee size.
3. In pipe 3 inches and larger: install the element in the flow.

O. Low Limit Thermostats (Freezestats):

1. Install low limit controls where indicated on the drawings or as specified. Unless otherwise indicated, install sensing element on the downstream side of heating coils.
2. Mount units using flanges and element holders. Provide duct collars or bushings where sensing capillary passes through sheetmetal housings or ductwork; seal this penetration to eliminate air leakage. Mount the units in an accessible location as to allow for resetting after low limit trips while still meeting manufacturer's installation requirements for proper function.
3. Distribute (serpentine) sensing element horizontally across the coil to cover every square foot of coil; on larger coils this may require more than one instrument. Install controls at accessible location with mounting brackets and element duct collars where required.

P. Liquid Flow Sensors

1. Install where indicated on the drawings and details for flow sensing in hydronic piping systems. Do not install close to elbows, valves, or other piping specialties, which might affect the reading of the sensor; follow manufacturer's installation instructions.
2. Location of remote mounted display shall be so that the flow measurement display shall be mounted four to five feet above finished floor. Refer to drawing detail for differential pressure transmitter piping detail. All piping to and from sensors shall be by Section 23 21 13 and 23 22 13 contractor and shall comply with requirements of Sections 23 21 13 and 23 22 13.

Q. Pressure Transducers and High Limit Pressure Switches

1. Install capped tees in air piping at air pressure transducers for connection of calibration equipment. Capped tee shall consist of two inch poly tubing capped with a brass plug. Rubber caps are not acceptable. Install Petes Plugs fittings at each take-off from main piping for liquid pressure transducers for connection of calibration equipment.
2. Install differential pressure transducers for filter monitoring at the filter section of the air handling unless otherwise specified. All other differential or static pressure transducers and differential or static pressure high limit switches for air applications should be mounted in the temperature control panel serving the equipment being controlled or monitored. All devices mounted on equipment shall be mounted in a location that is at a maximum of five feet above the floor. For liquid applications, provide shutoff valves at piping takeoff points.

R. Air Flow Stations:

1. Install airflow stations in accordance with manufacturer's recommendations. Install straightening vanes upstream of unit where required per manufacturers recommendations.

S. Temperature Control Panels:

1. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. All control panel openings shall be plugged. Conduits and other penetrations on the top of the cabinets shall be sealed on the exterior of the cabinet with silicone caulk to resist water penetration. One cabinet may accommodate more than one system in same equipment room. Provide permanent printed labeling for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
2. Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

T. Carbon Dioxide (CO2) Sensor

1. Provide a Carbon Dioxide (CO2) sensor for conference areas and return ductwork for AHU-A1 and E1. Refer to plan for locations of devices.

U. Differential Pressure Switches:

1. Provide for each fan or pump specified or shown on point list. Provide shutoff valves at piping takeoff points. Readjust pressure and/or differential setpoints for proper operation after final balancing is completed.

V. Current Status Switches:

1. Provide for each fan or pump specified or shown on point list. Set threshold adjustment to indicate belt or coupling loss. Readjust threshold for proper operation after final balancing is completed. Use the variable frequency drive (VFD) integrated relay output for motor status, if provided on the VFD, in lieu of a discrete current switch.

W. HVAC System - Emergency Shutdown

1. Contractor to install wall-mounted pushbutton switches for shutdown of the HVAC systems at the main entry/exit for the Administration Building. Refer to plan for locations of devices.

X. Boiler System - Emergency Shutdown

1. Contractor to install two wall-mounted pushbutton switches for shutdown of the boiler system at the main entry/exit for the Mezzanine Level – Area B. Refer to plan for locations of devices.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."

B. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Section 271500 "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install cable in conduit in the following locations:

    a. Exposed areas, such as mechanical rooms and electrical rooms.
    b. Inaccessible concealed spaces, such as above gypboard ceilings and in concrete or furred walls.

3. Install exposed cable in raceway.
4. Install concealed cable in raceway.
5. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

6. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
7. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
8. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
9. Route wires parallel or perpendicular to the building structural elements.
10. Do not route wires across telephone equipment areas.
11. In enclosures, install wiring in plastic track.
12. In controllers, wrap and secure all wiring.
13. Install wires at least 3 inches away from hot surfaces, such as steam and hot water pipes.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

F. Where the sensor voltage exceeds the controller's allowed input voltage, modify the circuit with resistor(s) so that the input voltage to the controller is as high as practical and below the controller's limit.

G. Provide transient voltage surge protection according to Division 26.

H. For equipment powered by emergency power, provide power to the equipment's controller from an emergency power panel.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
    a. Use manufacturer's linearity curve to lineraize the signal from each sensor.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated. Factory calibration does not replace field calibration.
4. Control System Inputs and Outputs:
    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:

a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 "Demonstration and Training."

1. The first training session, minimum 8 hours, shall take place just prior to Substantial Completion. Training shall include system operation, maintenance procedures, and operating the system software. Submit O&M manuals at least one week prior to training session.
2. A follow-up training session, minimum 4 hours, shall take place approximately six months after Substantial Completion to assist troubleshooting answer questions.
3. A second follow-up training session, minimum 4 hours, shall take place approximately twelve months after Substantial Completion (just before the end of the warrantee period) to assist troubleshooting answer questions.

END OF SECTION 23 09 00

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SECTION 23 09 24

DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SCOPE

A. The work associated with this section will be bid as part of the Division 23 scope of work.

B. Work in this section includes Direct Digital Control (DDC) panels, main communication trunk, software programming, and other equipment and accessories necessary to constitute a completely coordinated building Direct Digital Control (DDC) system. This system interfaced with Instrumentation and Controls for HVAC (Section 23 09 00) utilizing Direct Digital Control signals to operate actuated control devices will meet, in every respect, all operational and quality standards specified herein, a fully coordinated modification and extension via standard Web browser-IP address DDC of the City of Madison Automation System.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASCs, and operator devices.

D. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

1.2 RELATED WORK

A. Section 23 08 00 – Commissioning of HVAC.

B. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.

C. Section 23 09 00 – Instrumentation and Controls for HVAC.

D. Division 21 - HVAC - Equipment provided to be controlled or monitored.

E. Division 22 - HVAC - Equipment provided to be controlled or monitored

F. Division 26 - Electrical - Equipment provided to be controlled or monitored.

1.3 REFERENCE

A. Applicable provisions of Division 1 govern work under this section.

1.4 REFERENCE STANDARDS

A. FCC Part 15, Subpart J, Class A - Digital Electronic Equipment to Radio Communication Interference.

1.5 WORK NOT INCLUDED

A. Section 23 09 00 work includes furnishing and installing all field devices, including electronic sensors for the DDC of this section, equipment, and all related field wiring, interlocking control wiring between equipment, pneumatic tubing, sensor mounting, etc., that is covered in that section.

B. Motorized control dampers and actuators, thermowells (temperature sensing wells), automatic control valves and their actuators are also covered in Section 23 09 00.

1.6 DESCRIPTION

A. The DDC control work associated with this section shall be bid as part of the Temperature Control Contract scope of the Work.

B. The Building Automation System (BAS) shall be an based on a hierarchical architecture incorporating the Niagara AX Framework™ using Honeywell WEBs-AX™. All Building Management Functions shall be operable from the existing Honeywell workstations.

C. The BAS shall consist of the following:

1. AX Supervisor Lon Web Connection.
2. Building Operator's AX Supervisor Web Station.
3. WEBs-AX™ - Direct Digital Control Panels.
4. WEBs-AX™ 600 - Master Controls
5. Spyder Controllers Standalone Application Specific Controllers (ACSs).
6. LonWorks Network Wiring
7. City of Madison Lan/Wan Integration

1.7 UTILITY METER MONITORING

A. Electric Metering: The temperature control contractor shall arrange with the project electric utility for providing an isolation relay at the service electric meter to allow independent pulse signals to be monitored by the DDC control system for electric utility KWH power usage and peak KW demand. Cost for adding the isolation relay shall be paid for by the contractor.

1. The isolation relay requires a 120-volt 15-amp receptacle. The temperature control contactor is responsible for providing the necessary power for the isolation relay.
2. The temperature control contractor shall obtain the pulse signal multipiers from the utility

B. Natural Gas Metering: The temperature control contractor shall arrange with the project natural gas utility for providing a pulse transmitter at the service gas meter to allow independent pulse signals to be monitored by the DDC control system for gas utility gas consumption. Cost for adding the isolation relay shall be paid for by the contractor.

1. No power is required by the pulse transmitter.
2. The temperature control contractor shall obtain the pulse signal multipiers from the utility
3. Contractor shall provide power for the relay

1.8 OPEN COMMUNICATION

A. Industry standard Open Communication Protocols shall be provided as specified in the applicable communication sections.

B. LonWorks® compliance:

1. The fully integrated Honeywell WEBs-AX™ System shall be operable on the LonWorks® bus. General Purpose Controllers, Unitary Controllers, and PC-based centrals shall be able to operate and communicate on the 2-wire LonWorks® bus without the need of using gateways or drivers.
2. The Systems Integrator shall after all hardware (devices/nodes and wiring) has been installed provide all necessary device installation, device configuration, device diagnostics, network variable binding and systems diagnostics.
3. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each network controller shall communicate to LonMark™/LonTalk™ (IDC) and/or BACnet™ (IBC) controllers.

1.9 QUALITY ASSURANCE

A. Contractors/Installers:

1. Pieper Electric, Control Works, or Illingworth.

B. Installer Qualifications:

1. A firm specializing and experienced in DDC control system installation with a local service office within 60 miles of Madison and experience with similar installations for no less than five (5) years. All work to be done by qualified mechanics in the direct employ of this manufacturer.
2. All engineering and commissioning work shall be done by qualified personnel in the direct employ of this manufacturer, or of an Authorized Representative of that manufacturer that provides engineering and commissioning of the manufacturers control equipment.
3. Where installing contractor is an authorized representative of the control equipment manufacturer, submit written confirmation of such authorization. Indicate in letter of authorization that the installing contractor has successfully completed all necessary training required for the engineering, installation, and commissioning of equipment and systems to be provided for the project, and that such authorization has been in effect for a period of not less than three years.

C. Response Time:

1. During warrantee period, four (4) hours or less, 24-hours/day, 7 days/week.

D. Authorized Controls Integrator:

1. The control contractor shall be a Honeywell ACI – Authorized Integrator.

E. Electrical Standards:

1. Provide electrical products, which have been tested, listed and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards.
2. DDC Standards: DDC manufacturer shall provide written proof with shop drawings that the equipment being provided is in compliance with FCC rules governing the control of interference caused by Digital Electronic Equipment to Radio Communications (Part 15, Subpart J, Class A).

1.10 SUBMITTALS

A. Include the following information:

1. Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Indicate which piece of mechanical equipment is associated with each controller and what area within the building is being served by that equipment. For terminal unit control, provide a room schedule that lists mechanical equipment tag, room number of space served, address of DDC controller, and any other pertinent information required for service.

1.11 PRODUCT DATA:

A. Submit manufacturer's specifications for each control device furnished, including installation instructions and startup instructions. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked. Annotated software program documentation shall be submitted for system sequences, along with descriptive narratives of the sequence of operation of the entire system involved. Shop drawings shall also contain complete software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Submit wiring diagram for each electrical control device along with other details required to demonstrate that the system has been coordinated and will function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

B. All control devices in public areas shall be selected by Architect from one of the manufacturer’s standard colors.

C. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or City's representative.

1.12 MAINTENANCE DATA:

A. Submit maintenance data and spare parts lists for each control device. Include this data in maintenance manual.

1.13 RECORD DRAWINGS:

A. Prior to request for final payment provide complete composite record drawings to incorporate the DDC and Electric fieldwork. Provide application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Copies of the record drawings shall be provided in addition to the documents on compact disk. All record drawings shall also be installed into the BAS server in a dedicated directory. Accurate Section 23 09 00 record drawings to be supplied by the Section 23 09 00 Contractor with the accuracy of these drawings being the responsibility of the 23 09 00 contractor. In the event that changes are required to the 23 09 00 supplied record drawings after they have been compiled by the 23 09 24 contractor, it shall be the 23 09 00 contractors responsibility to provide updated composite record drawings incorporating the 23 09 24 record drawings.

B. All software addressing for device communication shall be noted for all devices provided under this section and the communication addressing required for devices provided by others that are integrated into the direct digital control system provided under this section. Coordinate with the supplier of the equipment specified to be interfaced through digital communications for communication addressing. Provide circuit number of 120VAC panel power circuit(s) feeding each control panel on record drawings. Label circuit number(s) inside the panel served.

C. Prior to request for final payment, provide complete composite record drawings to incorporate the DDC and Electric fieldwork.

1.14 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.15 MATERIAL DELIVERY AND STORAGE

A. Provide factory-shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

PART 2 - PRODUCTS

2.1 NETWORKING/COMMUNICATIONS

A. The design of the BAS shall be networked as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via a local network or a standard Web browser. A combination of the two networking schemes.

B. City to provide network connections for the network Honeywell JACE 600 controllers.

C. Local Network:

1. Building Operator's Station /Panel Support:

a. The Building Operator's Station or Digital Panel shall directly oversee a local network such that communications may be executed directly to and between ASCs. The Operator's Terminal version or Digital Panel version shall be referred to as the "Digital Panel(s)" throughout this document.

D. Data Access:

1. All operator devices either network resident or a standard Web browser, shall have the ability to access all point status and application data on the network.
2. Access to system data shall not be restricted by the hardware configuration of the BAS.
3. All operators shall have the ability to collect data for any property of any object and store this data for future use.
4. The data collection shall be performed by log objects, resident in the controller that shall have, at a minimum, the following configurable properties:

   a. Designating the log as interval or deviation.
   b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
   c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
   d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
   e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

E. All log data shall be stored in a relational database in the controller and the data shall be accessed from a server (if the system is so configured) or a standard Web browser. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

F. All log data shall be available to the user in the following data formats:

1. HTML (deal breaker).
2. XML (deal breaker).
3. Plain Text.
4. Comma or tab separated values.
5. PDF.

G. All operators shall have the ability to archive its log data either locally (to itself), or remotely to a server or other controllers on the network. Provide the ability to configure the following archiving properties, at a minimum:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

H. Measured and calculated analog and binary data shall be assignable to user definable trends for the purpose of collecting operator specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one minute or one hour intervals, shall be provided. Each supervisory controller shall have a dedicated buffer for trend data and shall be capable of storing 16 trend logs. Each trend log shall have up to four points trended at 48 data samples each. Data shall be stored at the supervisory controller and up-loaded to the DDC system server when archiving is desired.

I. Supervisory controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis, user defined, for user-selected analog and binary pulse input type points.

1. Totalization shall provide calculation and storage accumulations of up to 9,999,999 units (e.g., KWH, gallons KBTU, tons, etc.).

2. The totalization routine shall have a sampling resolution of one minute.
3. The user shall have the ability to define a warning limit. Unique, user specified messages shall be generated when the limit is reached.
4. The information available from pulse totalization shall include, but not be limited to, the following:

    a. Peak demand, with date and time stamp.
    b. 24-hour demand log.
    c. Accumulated KWH and therms for day.
    d. Sunday through Saturday KWH and therm usage.
    e. Demand KW annual history for past 12 periods.
    f. KWH and therm annual history for past periods.

J. Supervisory controllers shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off.

K. The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

L. Global Data Sharing: global Data Sharing or Global point broadcasting shall allow point data to be shared between ASCs, when it would be inefficient or impractical to locate multiple sensors.

M. General Network Design: Network design shall include the following provisions:

N. Data transfer rates for alarm reporting and quick point status from multiple ASCs. The minimum baud rate shall be 9600 baud.

O. Support of any combination of ASCs. A minimum of 100 ASCs shall be supported on a single local network. The bus shall be addressable for up to 255 ASCs.

P. Detection of single or multiple failures of the ASCs or the network media.

Q. Error detection, correction, and retransmission to guarantee data integrity.

R. Commonly available, multiple sourced, networking components shall be used.

S. Use of an industry standard protocol, such as Optomux, and IEEE RS-485 communications interface.

T. The HVAC BAS provided under this section of the specifications shall consist of a distributed Client-Server, Local Area Network (LAN) based system, a dedicated local area network, routers, switchers, network nodes, direct digital control system and software to provide interoperability with the server software. The system is to be furnished and installed in its entirety by this supplier.

U. The HVAC BAS shall be modular in design and scaleable in implementation from an initial installation of a single server with minimum of two concurrent operator workstations to a system with up to 40 concurrent operator workstations, unlimited web browser access (using Internet Explorer) to system information for monitoring and control functions, and field controller network interfaces to permit expansion to 60,000 physical hardware points.

2.2 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™ or Firefox. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS, shall not be acceptable.

C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface (if used). Systems that require different graphic views, different means of graphic generation, or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

D. The Web browser client shall support at a minimum, the following functions:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

    a. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
    b. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

2. Storage of the graphical screens shall be in the All operators/controllers, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
3. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
4. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

    a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
    b. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    c. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    d. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No text entry shall be required.
    e. View logs and charts.
    f. View and acknowledge alarms.
    g. Setup and execute SQL queries on log and archive information.

5. The system shall provide the capability to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to set a specific home page for each user. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
6. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.3 DIGITAL PANELS

A. General: Digital Panels shall be microprocessor-based, multi-tasking, multi-user, digital control processors.

B. Memory: Each Digital Panel shall have sufficient memory to support its own operating system and databases including:

1. Control Processes.
2. energy Management Applications.
3. Alarm Management.
4. Trend Data.
5. Maintenance Support Applications.
6. Operator I/O.
7. Dial-Up Communications.

8. Manual Override Monitoring.

C. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of field controllers, sensors, and actuators.

D. Serial Communication Ports: Digital Panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as laptop computers, Personal Computers, and Video Display terminals.

E. Hardware Override Monitoring: Digital Panels shall monitor the status of al overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

F. Integrated On-Line Diagnostics: Each Digital Panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The Digital Panels shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each Digital Panel.

G. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

H. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of the Digital Panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

I. Upon restoration of normal power, the Digital Panels shall automatically resume full operation without manual intervention.

2.4 SYSTEM SOFTWARE FEATURES

A. General:

1. All necessary software to form a complete operating system as described in this specification shall be provided.
2. The software programs specified in this section shall be provided as an integral part of the Digital Panel and shall not be dependent upon any higher level computer for execution.

B. Graphic Requirements: Provide color graphic backgrounds with operational information interface for the following systems:

1. Hot water hydronic system with pumps, boilers and related.
2. Chilled water hydronic system with pumps, chillers and related.
3. Condenser water hydronics system with pumps, tower and related.
4. Air handling system with AHU-1 with RF-1 with dual wheels.
5. Air handling system with AHU-2 with RF-2.
6. Air handling system with AHU-3 with RF-3.
7. Air handling system AHU-4 (Energy Recovery Unit).
8. Each VAV terminal and perimeter radiation.
9. Each underfloor Fan Power Box FPB and associated Perimeter Trough Unit PTU.
10. Groups of underfloor air terminal diffuser.
11. Each In-floor radiant manifold RFM.
12. Reclaim System with pumps serving domestic water.
13. Exhaust Fans.
14. Building Floor Plan graphic for temperature sensor information and terminal unit service designations.

C. Control Software Description:

1. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
2. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
3. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

D. Energy Management Applications: Digital Panels shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling.
2. Calendar Based Scheduling.
3. Holiday Scheduling.
4. Temporary Schedule Overrides.
5. Optimal Start.
6. Optimal Stop.
7. Demand Limiting.
8. Load Rolling.
9. Heating/Cooling Interlock.
10. Average/High/Low Signal Select and Reset.

E. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the “Execution” portion of this specification.

F. Programming Capability: Digital Panels shall be able to execute configured processes defined by the user, to automatically perform calculations and control routines.

G. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

1. Any system-measured point data or status.
2. Any calculated data.
3. Any results from other processes.
4. Boolean logic operators (and, or,).

H. Process Triggers: Configured processes may be triggered based on any combination of the following:

1. Time of Day.
2. Calendar Date.
3. Other Processes.
4. Events (e.g., point alarms).

I. Data Access: A single process shall be able to incorporate measured or calculated data from any and all other ASCs.

1. In addition, a single process shall be able to issue commands to points in any and all other NCUs on ASCs local network.

J. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each Digital Panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the Digital Panel’s ability to report alarms be affected by either operator activity at the local I/O device, or communications with other ASCs on the network.

K. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to more fully describe the alarm condition or direct operator response.

L. Each Digital Panel shall be capable of storing a library of at least 100 Alarm Messages. Each message may be assignable to any number of points in the panel.

M. Auto-Dial Alarm Management: In dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

N. Trend Analysis: A data collection utility shall be provided to automatically sample, store and display system data.

O. Measured and calculated analog and binary data shall be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one-minute or one-hour intervals, shall be provided. Each Digital Panel shall have a dedicated buffer for trend data, and shall be capable of storing 32 trend logs. Each trend log shall have up to 4 points trended at 268 data samples each. data shall be stored at the Digital Panel.

P. Runtime Totalization: Digital Panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the “Execution” portion of this specification.

1. The Totalization routine shall have a sampling resolution of one minute.
2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

Q. Event Totalization: Digital Panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.5 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each Digital Panel shall be able to extend its performance and capacity through the use of standalone Application Specific Controllers (ASCs).

B. Each ASC shall operate as a standalone controller capable of performing its specific control responsibilities independently of other controllers in the network. Each ASC shall be of microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases including:

1. Control Processes.
2. Energy Management Applications.
3. Operator I/O (Portable Service Terminal).

D. The operator interface to any ASC point data or programs shall be through the Digital Panel or portable operator's terminal connected to any ASC on the network.

E. ASCs shall directly support the temporary use of a portable service terminal that can be connected to the ASC via zone temperature or directly at the controller. The capabilities of the portable service terminal shall include, but not be limited to, the following:

1. Display temperatures.
2. Display status.
3. Display setpoints.
4. Display control parameters.
5. Override binary output control.
6. Override analog setpoints.
7. Modification of gain and offset constants.

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

2.6 APPLICATION DESCRIPTIONS:

A. VAV Terminal Unit Controllers:

1. VAV Terminal Unit Controller shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements described in the "Execution" portion of this specification, for future expansion.
2. Single Duct Only (Cooling Only, or Cooling with Reheat).
3. Fan Powered (Parallel/Side Pocket, Series On/Off Logic Series/Proportional Fan).
4. Supply/Exhaust.

B. VAV Terminal Unit Controller shall support the following types of point inputs and outputs:

1. Proportional Cooling Outputs.
2. Box and Baseboard Heating Outputs.
3. (Proportional or 1 to 3 Stages).
4. Fan Control Output.
5. (On/Off Logic, or Proportional Series Fan Logic).

C. VAV Terminal Unit Controllers shall support the following library of control strategies to address the requirements of the sequences described in the "Execution" portion of this specification, and for future expansion:

1. Daily Schedules.
2. Comfort/Occupancy Mode.
3. Economy Mode.
4. Standby Mode.
5. Unoccupied.
6. Shutdown.
7. Lighting Logic Interlock to Economy Mode.
8. Temporary Override Mode.

D. Alarm Management: Each VAV Terminal Unit Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

E. Unitary Controllers:

F. Unitary Controllers shall support, but not be limited to, the following types of systems to address specific applications described in the "Execution" portion of this specification, and for future expansion:

1. In-Floor Radiant Manifold systems (Chilled/Hot Water).
2. Air Handling Units.
3. Generic Point Multiplexing.

G. Unitary Controllers shall support the following types of point inputs and outputs:

1. Economizer Switchover Inputs:

    a. Drybulb.
    b. Outdoor Air Enthalpy.
    c. Differential Temperature.
    d. Binary Input from a separate controller.

2. Economizer Outputs:

    a. Integrated Analog with minimum position.
    b. Binary Output to enable self-containe.
    c. Economizer Actuator.

3. Heating and Cooling Outputs:

    a. 1 to 3 Stages.
    b. Analog Output with two-pipe logic.
    c. Reversing valve logic for Heat Pumps.

4. Fan Output:

    a. On/Off Logic Control.

H. Unitary controllers shall support the following library of control strategies to address the requirements of the sequences described in the "Execution" portion of this specification, and for future expansion:

1. Daily Schedules.
2. Comfort/Occupancy Mode.
3. Economy Mode:

    a. Standby Mode/Economizer Available.
    b. Unoccupied/Economizer Not Available.
    c. Shutdown.

4. Lighting Logic Interlock to Economy Mode.
5. Temporary Override Mode:

    a. Temporary Comfort Mode (Occupancy-Based Control)
    b. Boost (Occupant Warmer/Cooler Control)

I. Alarm Management: Each VAV Terminal Unit Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

J. AHU Controllers:

1. AHU Controllers shall support, but not be limited to the following configurations of systems to address current requirements as described in the "Execution" portion of this specification, and for future expansion:

    a. Air Handling Units:

        1) Mixed Air-Single Path.
        2) Mixed Air-Dual Path.
        3) 100% Single Path.
        4) 100% Dual Path.
        5) Generic Point Multiplexing.

K. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

L. AHU controllers shall have a library of control routines and program logic to perform the sequence of operation as specified in the “Execution” portion of this specification.

M. Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously, maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

N. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

O. Each AHU Controller shall come with a hand-held Zone Terminal permanently mounted at the controller to allow interface with the controller. This device will allow the user to monitor or adjust set points and time scheduling within a specific zone.

P. Lab and Central Plan (LCP) Controllers:

1. LCP controllers shall support, but not be limited to, the following configurations of systems to address current requirements described in the “Execution” portion of this specification, and for future expansion.

    a. Single boiler or chiller plants with pump logic
    b. Cooling towers
    c. Air Handling Units with complex controls sequences
    d. Plant Heating and Cooling circuits

2. Heat exchangers

    a. LCP controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion. A minimum of 30 I/O points expandable to 94 shall be supported by the LCP.

2.7 OPERATOR INTERFACE

A. Basic Interface Description.

B. Command Entry/Menu Selection Process: Operator interface software shall minimize operator training through the use of English language prompting, English language point identification.

C. The operator interface shall have the option of using a mouse or similar pointing device for a “point and click" approach to facilities management. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

D. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit control, display and database manipulation capabilities as he deems appropriate for each user, based upon an assigned password. Provide secure password access to all features, functions and data contained in the overall BAS.

E. Passwords shall be exactly the same for all operator devices.

F. A minimum of four (4) levels of access shall be supported:

1. Level 1 = Data Access and Display.
2. Level 2 = Level 1 + Opera.tor Overrides and Commands.
3. Level 3 = Level 2 + Operator Management.

4. Level 4 = Level 3 + Database Generation and Modification.

G. A minimum of eight (8) passwords shall be supported at each Digital Panel.

H. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, shall be limited to only those items defined for the access level of the password used to log-on.

I. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices logged on.

J. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

1. Start-up or shutdown selected equipment.
2. Adjust setpoints.
3. Add/Modify/Delete time programming.
4. Enable/Disable process execution.
5. Lock/Unlock alarm reporting for each point.
6. Enable/Disable Totalization for each point.
7. Enable/Disable Trending.
8. Enter temporary override schedules.
9. Define Holiday Schedules.
10. Change time/date.
11. Enter/Modify analog alarm limits.
12. Enable/Disable demand limiting.
13. Enable/Disable duty cycle.
14. Enable/Disable average/high/low signal select and reset.

K. Logs and Summaries: Reports shall be generated manually, and directed to the displays. As a minimum, the system shall allow the user to easily obtain the following types of reports:

L. A general listing of all points in the network shall include, but not be limited to, the following:

1. Points currently in alarm.
2. Off-line points.
3. Points currently in override status.
4. Points in Weekly Schedules.
5. Holiday Programming.

M. Summaries shall be provide for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

N. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

O. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

1. Add/Delete/Modify Application Specific Controllers.
2. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants.
3. Add/Delete/Modify alarm reporting definition for each point.
4. Add/Delete/Modify energy management applications.
5. Add/Delete/Modify time- and calendar-based programming.

6. Add/Delete/Modify Totalization for every point.
7. Add/Delete/Modify Historical Data Trending for every point.
8. Add/Delete/Modify configured control processes.
9. Add/Delete/Modify dial-up telecommunication definition.
10. Add/Delete/Modify all operator passwords.
11. Add/Delete/Modify Alarm Messages.

P. Programming Description: Definition of operator device characteristics, ASCs, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.

Q. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data.

R. Database Save/Restore/Back-Up: Back-up copies of all ASC and Digital Panel databases shall be stored in at least one personal computer or laptop. Users shall also have the ability to manually execute downloads of an ASC or Digital Panel data base.

S. Interface with City of Madison Central BAS System: Provide a standard Web browser with IP address for connection to existing City Central BAS System. Update graphics on City Central BAS System as required to allow central monitoring of this project control system.

T. Graphical User Interface Computer Hardware (Desktop):

1. Contractor shall provide 2 network ports in or near mechanical room. Exact location to be provided by owner on site. Coordinate with Owner’s Representative on interface with their computer hardware desktop.

PART 3 - EXECUTION

3.1 GENERAL

A. This contractor shall provide all labor, materials, engineering, software permits, tools, check-out and certificates required to install a complete DDC automation system as herein specified. This system expansion shall be compatible with and interfaced to the existing computer driven automation center on campus, and shall operate through all the existing I/O devices, central processing unit (CPU), and digital communication trunks. This connection to the digital communications trunk shall be true bi-directional analog and digital communications with the existing central campus automation system.

B. Any and all points added with this project shall be properly interfaced into the existing City’s existing central automation system via standard Web browser-IP address format and grouped for display purposes into the system such that all points associated with a new or existing DDC system can appear together on the CRT display or printed log. Assignment of points to a group shall not be restricted by hardware configuration of the points of direct digital control. It shall be possible to assign a point to appear in more than one system. An English descriptor and an alpha/numeric identifier shall identify each system.

C. This City’s central automation system expansion as herein specified shall be fully integrated and completely installed by this section. It shall include all required computer CPU software and hardware. Include the engineering, installation, supervision, calibration, software programming, and checkout necessary for a fully operational system.

D. Mechancial drawings of the system and BAS network are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the Engineer shall be furnished and installed without additional cost.

3.2 INSTALLATION

A. Install the control system in accordance with manufacturer's instructions.

B. All work and materials are to conform in every detail to the rules and requirements of the National Electrical Code and any applicable local codes, and present manufacturing standards. All wiring and cable installation shall conform with the wiring installation as specified in the installation section of Section 23 09 00. All material shall be UL approved.

C. Where plenum rated cable wiring is allowed it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

D. The addition of this specified system expansion shall in no way impair the future capabilities of any existing functions of the computer driven existing City central campus automation system. A system expansion with lessor capabilities will not be accepted. Further, this contractor will not put in jeopardy the normal, uniterruptable operation of the entire campus automation system the time it is interfaced through the completion of this project.

E. Install system and materials in accordance with manufacturer's instructions, rough-in drawings and details on drawings.

F. Line voltage wiring to power the DDC Controllers, not provided by the Division 26 contractor, to be by this contractor.

G. Project has limited centralized UPS backup power for egress lighting. Any control panels serving equipment needing anyu mimimu backup power shall have individual UPS systems.

H. Control panels shall not be installed in raised floor systems or concealed areas. All panels shall be accessible and serviceable which will provide minimal disruption to the building occupant or function. Consult with maintenance operation staff for recommended locations. Final location shall be decided by the Owner’s Project Represenative.

I. Provide uninterruptable power supplies where necessary to provide proper startup of equipment or to accomplish power restart control sequences specified.

J. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide printed plastic tags for instruments and controls inside cabinet and on engraved plastic nameplates cabinet face.

K. Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

L. Extension of the data-net between DDC Controllers and to existing Campus Automation System (LAN) Local Area Network to be by this contractor. Cable tray routing of the communication trunks is acceptable.

M. Provide an input for a service shutdown toggle switch for each air handling unit system provided inside the (Section 23 09 00) temperature control panel that will initiate a logical shutdown of the air handling unit system.

N. All cables to the DDC panels shall be extended by the electric controls contractor (Section 23 09 00) in the DDC panel with sufficient spare cable (minimum of 5') to allow termination by the DDC Contractor.

O. Electric controls system contractor (Section 23 09 00) shall provide a field mechanic and system technician to inspect and validate all tubing and wiring associated with the DDC contractor (Section 23 09 24).

3.3 ACCEPTANCE TESTING

A. Upon completion of the installation, this contractor shall load all system software and start-up the system. This contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.

B. his contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log. Schedule with the Commissioning Agent, CxP, that allows in advance notice of 5 business days of the testing so that the CxP may witness as deemed necessary. Also notify the Owner's Representative, as required. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

D. System Acceptance: Satisfactory completion is when all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the CxP, Engineer, and Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.4 DEMONSTRATION

A. The system manufacturer or his representative shall provide start-up and adjustment service for the control system.

B. The system manufacturer or his representative shall provide a minimum eight (24) hours of training for the Owner's personnel on the operation and maintenance of the packaged control system.

3.5 TRAINING

A. All training provided for personnel shall comply with the format, general content requirements and submission guidelines specified under Section 01820.

B. Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 8 hours for total of 24 hours.

C. Contractor to provide 24 hours of instruction training to the owner's designated personnel on the operation of the the system and describe its intended use with respect to the programmed functions specified. Operator orientation of the systems shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part tof the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.

D. The instructional training shall be in two sessions as follows:

1. Initial Instructional Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the owners' personnel can start to familiarize themselves with the system before classroom instruction begins.
2. First Follow-Up Instructional Training: Two days (16 hours total) approximately two weeks after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics such as data collection, event counting and answer questions.

E. Provide two follow-up visits for troubleshooting and instruction, one six months after substantial completion and the other at the end of the warranty period. Length of each visit to be not less than 2 hours or the time necessary to provide required information and complete troubleshooting and inspection activity for all controls installed under this section. Coordinate the visit with the City and provide an inspection report to the Owner's representative of any deficiencies found.

3.6 COMMISSIONING

A. The contractor shall provide web access via Web browser-IP address to the Commissioning Agent and/or Engineer to enable access to and from the server.

END OF SECTION 23 09 24

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SECTION 23 09 93

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:

1. Section 230900 "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. BAS: Building Automation System

C. VAV: Variable air volume.

D. Inches w.g.: Inches of water gauge, or inches of water column.

1.4 GENERAL

A. A value in this specification followed by the word “adjustable” means the value can be changed manually through the DDC system by the Owner.

B. All duct mounted smoke detectors shall be provided and installed by this contractor. 120/1 electrical power to the detectors will be provided by the Electrical Contractor. ALL other required wiring to achieve a complete and fully functioning duct smoke detection system that is California code and NFPA standard compliant as well as acceptable to the local authority having jurisdiction. Wire all duct smoke detectors to a single remote alarm horn and trouble annunciator alarm wall mounted in a normally occupied area. Verify alarm horn and trouble annunciator location with Owner.

C. The DDC control systems shall be connected to the main fire suppression control panel. When this fire suppression system is activated, the fire suppression system shall shut down ALL equipment fan motors via the DDC temperature system. This contractor shall provide all materials and labor required for this control feature. The fire suppression system panel and its programming shall be by others.

D. All control points shall be exposed as BACnet objects and shall be viewable and editable over the internet from a remote location with a standard web browser.

E. For pushbutton switches mentioned in the sections below, provide the Owner with a sample of each type used for approval prior to installation.

F. When filter pressure monitoring and control is required for a unit, filter monitoring and control shall apply to all filter banks in the unit.

G. Setpoints:

1. All setpoints indicated in the control specification are to be adjustable. The setpoints shall be readily available to be modified in the mechanical system software system summary (either textual or graphic based) and under the same software level as hardware points. Some less used setpoints may be provided on a lower software level, if requested by the Owner for clarity. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on requirements of the building. The control contractor shall work with the balancing contractor and the Owner to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use. Document all final setpoints on the as-built control drawings. Any questions regarding the intended operation of the HVAC equipment and control systems shall be referred to the HVAC design engineer through the appropriate construction communication process. The following setpoints should be used as initial setpoints unless otherwise specified in the individual control sequences or instructed by the user Agency. If the contractor fails to check with the user Owner for final setpoints, they shall adjust setpoints at no additional cost.

   a. Occupied Space Terminal Unit Heating: 68 deg F
   b. Occupied Space Terminal Unit Cooling: 75 deg F
   c. Unoccupied Space Terminal Unit Heating: 60 deg F
   d. Unoccupied Space Terminal Unit Cooling: 80 deg F

H. Anti-cycling:

1. When HVAC equipment or a sequence is specified to be started and stopped by a temperature, pressure setpoint or any other controlled variable, there shall be an adjustable differential setpoint that shall be set to prevent short cycling of the systems and equipment due to minor changes in the controlled variable. Temperature differential setpoints shall be set at 2 deg F and non-temperature setpoints shall be set at 10% of the controlled range unless otherwise specified. Setpoints shall indicate at when the process should be turned on. Heating and cooling differentials shall be set for above setpoint and shall be used to turn the process off. For example, an economizer sequence called to switch at 68º F, would turn on at 68 deg F and off at 70 deg F since it is a cooling function. A heating lockout setpoint of 50º F would turn on heating control at 50 deg F and off at 52 deg F Non-temperature differentials shall be set above setpoint if the setpoint is indicating a minimum value or below setpoint if the setpoint is indicating a maximum value. Provide minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans shall have a minimum runtime on timers of 15 minutes (adj.) and off timers of 5 minutes (adj.). Safeties shall override runtime timers.

I. Deadbands:

1. Provide deadbands for all DDC control loops to prevent constant hunting of output signals to controlled devices. Deadbands shall be set to provide adequate control around setpoint as follows unless otherwise specified in the individual control sequences:

   a. Temperature Control: ±0.5 deg F
   b. Humidity Control: NA
   c. Airflow Control: ±2% of total flow
   d. AHU Static Pressure Control: ±0.01 in. w.c.

J. Alarms:

1. Provide all alarmed points with adjustable time delays to prevent nuisance tripping under normal operation and on equipment start-up. For all commanded outputs that have status feedback, provide an alarm that

shall indicate the commanded output is not in its commanded state. Provide alarms on all points as indicated on point charts. For existing campus automations systems, add/delete what is called on the point charts for after consultation with user Agency to provide consistent alarming throughout the automation system.

2. For devices that have form "C" contacts available for alarm monitoring, use closed contacts for the Normal condition and open contacts on Alarm condition. This shall provide a level of supervision by detecting a break in the wiring.

K. Equipment Start/Stop Failure States:

1. All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

L. Variable Frequency Drive (VFD) Motor Run Status:

1. Use the VFD programmable relay dry contact output specified to be provided with the VFD under Section 23 05 14 to prove motor run status and detect belt loss or coupling break.

M. VFD Minimum Speed & Ramp Timers:

1. The VFD start-up technician shall work with the DDC Temperature Control Contractor determine the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP.

N. Current Switch Setup:

1. When current switches are used for proving fan status, they shall be set up so that they will detect belt or coupling loss by the reduction in current draw on loss of coupled load. The current switch set up shall be redone by the 23 09 00 contractor after the balancer is complete.

O. Damper Interlocks for Fans with ECM motors:

1. For fan systems with ECM motors and shutoff dampers specified with end switches, the damper interlock shall be hardwired in such a way that the damper shall open if the fan starter hand / off / auto switch is in the hand or in the auto position and being called to start. After the damper end switch has proven the damper open, a hardwire interlock from the end switch to the starter holding coil for the fan shall cause the fan to start.

P. Damper Interlocks for Fans with VFD's:

1. For fan systems with VFD's and shutoff dampers specified with end switches, the damper end switches shall be hardwire interlocked to the safety circuit(s) of the VFD to prevent the fan from starting until the damper is proven open. The damper end switch shall also be monitored by the DDC system.

Q. Fan Interlocking:

1. Provide interlocks between supply and return or exhaust fan systems as scheduled on the plans or called out in individual control sequences. If DDC controlled, interlocks shall be done through DDC start/stop points unless otherwise specified in individual control sequences. If not DDC controlled, interlocks shall be accomplished via hardwire interlocks between fan starters or VFD's.

R. Thermostats and Sensors:

1. All devices and equipment including terminal units, specified to be controlled in a control sequence by a thermostat or sensor, shall be provided with a thermostat or sensor, whether or not the device is indicated on the plans.

S. Watch Dog Timer:

1. Where the integrated system consists of programmable DDC controllers with BACnet objects mapped to an enterprise level Building Automation System (BAS) and it is shown that the BACnet objects do not indicate when they are offline on the enterprise level BAS when communication is lost between the two systems, software algorithms shall be provided to alarm when communication is lost. The integrated system shall program a binary data object that is toggled on and off at an adjustable rate (initially one minute) that shall be monitored by the enterprise level BAS which shall alarm if the toggling ceases.

T. Weekly Scheduling:

1. Provide scheduling of DDC terminal units based on occupancy. Work with the user Owner to determine scheduling and which zones should be included. Individual terminal units shall be able to receive temporary schedules that shall override the group schedules. Temporary override buttons at the zone sensor (where specified on point charts) shall override the scheduling to occupied. When 20 % or more terminal units are indexed to occupied, the associated air handling unit shall start if not already running.

U. DDC Controller Communication Bus Configuration:

1. The actively controlled primary mechanical equipment (VFDs, meters, gas detection, destratification fans etc.) DDC controllers shall be configured to be located on the same supervisory controller BACnet MSTP communication trunk unless the supervisory controller capacity prevents it. If this is the case, the primary mechanical equipment DDC controllers shall be separated onto supervisory controllers in such a way that the systems that need to share information for operation and interlocking shall reside on the same supervisory controllers. Other critical building systems that require communication between DDC controllers to operate shall be on the same BACnet MSTP communication trunk. Terminal unit controllers shall be located on a separate BACnet MSTP trunks, if necessary, to allow for primary equipment to reside on the same BACnet MSTP trunk. If the DDC controllers used for control of primary mechanical equipment and interlocks or point information is required for proper operation as described above do not use BACnet MSTP communication but use Ethernet communication, the DDC controllers shall be connected to the same Ethernet switch. If the controllers cannot be connected to the same switch, hardwired points between controllers shall be used to share information.

V. Utility Meter Monitoring:

1. Provide DDC programming to define all metering integral input/output points, setpoints, data points, calculations, etc. The following utility meters shall be integrated into the BAS DDC system.
2. Electric Metering: The Temperature Control Contractor shall arrange with the project electric utility for providing an isolation relay at the service electric meter to allow independent pulse signals to be monitored by the DDC control system for electric utility KWH power usage and peak KW demand.

    a. The isolation relay requires a 120-volt 15-amp receptacle. The temperature control contactor is responsible for providing the necessary power for the isolation relay.
    b. The Temperature Control Contractor shall obtain the pulse signal multipliers from the utility.

3. Natural Gas Metering: The Temperature Control Contractor shall arrange with the project's natural gas utility for providing a pulse transmitter at the service gas meter to allow independent pulse signals to be monitored by the DDC control system for gas utility gas consumption of the building. No power is required by the pulse transmitter.

a. The temperature control contractor shall obtain the pulse signal multipliers from the utility

4. Water Metering: The Temperature Control Contractor shall arrange with the City of Madison water utility for providing a pulse transmitter at the service water meter to allow independent pulse signals to be monitored by the DDC control system for water consumption of the building. No power is required by the pulse transmitter

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 Refer to Mechanical drawings M-800 Series for Sequence of Operations for HVAC Controls.

END OF SECTION 23 09 93

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SECTION 23 11 23

FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 2psig.

B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig but not more than 5 psig and is reduced to secondary pressure of more than 0.5 psig but not more than 2 psig.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Pipe and Fittings: See drawing schedule for pipe and fitting material requirements

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.

7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Lee Brass Company.
   b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
6. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. McDonald, A. Y. Mfg. Co.
   b. Mueller Co.; Gas Products Div.
   c. Xomox Corporation; a Crane company.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.

9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Ventless

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturer: Basis-of-Design Product: The design is based on the following:

   a. Maxitrol 325

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Actaris.
   b. American Meter Company.
   c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   d. Norgas Controls
   e. Invensys.

3. Body and Diaphragm Case: Cast iron or die-cast aluminum.
4. Springs: Zinc-plated steel; interchangeable.
5. Diaphragm Plate: Zinc-plated steel.
6. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
7. Orifice: Aluminum; interchangeable.
8. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
9. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
10. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Overpressure Protection Device: Factory mounted on pressure regulator.
12. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturer: Basis-of-Design Product: The design is based on the following:

   a. Maxitrol RV Series

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Canadian Meter Company Inc.
   b. Eaton Corporation; Controls Div.
   c. Harper Wyman Co.
   d. SCP, Inc.

3. Body and Diaphragm Case: Die-cast aluminum.
4. Springs: Zinc-plated steel; interchangeable.
5. Diaphragm Plate: Zinc-plated steel.
6. Seat Disc: Nitrile rubber.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
9. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
10. Maximum Inlet Pressure: 1 psig.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

C. Install fittings for changes in direction and branch connections.

D. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.

R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

S. Do not use natural-gas piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

C. Provide additional intermediate supports as required so deflection of piping does not exceed 1/240 of span.

D. Support spacings listed above are minimum requirements. Contractor shall provide additional supports as required by codes or authority having jurisdiction at no additional cost to contract.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Exterior alkyd enamel matching topcoat.

c. Topcoat: Exterior alkyd enamel (gloss).
d. Color: Gray.

B. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Interior latex matching topcoat.
c. Topcoat: Interior latex (semigloss).
d. Color: Gray.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Prior to start-up, Contractor shall verify gas system pressure downstream of gas meter as indicated on plans. If meter pressure is not within ±5% of pressure indicated on plans, Contractor shall notify the Architect/Engineer and Owner immediately.

1. If a pressure tap is not available for connectors of a gas pressure gauge, one shall be installed at no additional cost to the Contract.

F. Downstream gas pressure measurement shall be taken within 15 feet of the gas meter discharge.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR AND INDOOR PIPING SCHEDULE

A. See pipe and valve schedule on drawings for piping materials schedule

3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. See pipe and valve schedule on drawings for piping materials schedule

END OF SECTION 23 11 23

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SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Chemical treatment.
2. Welding certificates.

1.3 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Makeup-Water Piping: 80 psig at 150 deg F.
3. Condensate-Drain Piping: 150 deg F.
4. Air-Vent Piping: 200 deg F.
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER FITTINGS

A. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

C. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

D. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

E. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 TRANSITION FITTINGS

A. See specification section 230500 – Common Work Results for HVAC.

2.6 DIELECTRIC FITTINGS

A. See specification section 230500 – Common Work Results for HVAC.

2.7 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Refer to piping schedule on drawings.

1. Contractor shall provide all pipe welding for carbon steel piping. Only HVAC equipment will be flange connections for this project.

2. Contractor shall provide all solder copper piping. Only HVAC equipment will be union connections for this project.

B. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

C. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

D. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "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 230517 "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 230500 "Common Work Results for HVAC."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.

2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

SECTION 23 21 16

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Makeup-Water Piping: 80 psig at 150 deg F.
3. Condensate-Drain Piping: 150 deg F.
4. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Nexus Valve, Inc.
    g. Tour & Andersson; available through Victaulic Company.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Nexus Valve, Inc.
    g. Tour & Andersson.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Spence Engineering Company, Inc.
    e. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless; removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Spence Engineering Company, Inc.
    e. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: stainless steel; removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump Model 4V
    d. Eaton/Dole Model 9, 9B, or 14A.
    e. Nexus Valve, Inc.

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 125 psig.
8. Maximum Operating Temperature: 220 deg F.

B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Nexus Valve, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 125 psig.
8. Maximum Operating Temperature: 220 deg F.
9. Designed to vent air automatically with float principle without allowing air to enter the system.

C. Bladder-Type Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Amtrol/Thrush
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. John Wood,
    e. Taco, Inc.
    f. Wessel

2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Provide a precharged with air to the initial fill pressure indicated on the drawings, butyl replaceable bladder suitable for propylene glycol and furnished with a tank drain connection, system connection, base for vertical installation, prime coated, size/capacity as indicated on the drawings.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
6. Tank and bladder construction must allow field replacement of the bladder on its failure.
7. Provide bladder rupture indicator with air valve release.

D. Coalescing-Type Air and Dirt Separators:

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. Spirotherm VDT.
    b. Wessel: WVA Series.

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig (862-kPa) working pressure and 270 deg F (130 deg C) maximum operating temperature.
3. Coalescing Medium: Copper or Stainless steel.
4. Air Vent: Threaded to the top of the separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to the bottom of the separator.

7. Size: Match system flow capacity and with pipe size as schedules on drainings. In no case shall entering velocity exceed 10 feet per second.

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig
5. Manufacturers: Armstrong, Hoffman, Illinois, Keckley, Metraflex, Mueller Steam, or Sarco.

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shut off-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, or air separator to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install expansion tanks on the floor. Vent air from hydronic system and ensure that tank is properly charged with air to suit system's project requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

3.4 COALESCING-TYPE AIR AND DIRT SEPARATORS:

A. Install coalescing type air and dirt separator for the hot water heating and solar heating systems.

END OF SECTION 23 21 16

SECTION 23 21 23

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.
4. Include NPSH curve when specified.
5. Certified dimension prints showing all necessary details of construction.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers Basis-of-Design Product: The design is based on the following:

1. Grundfos/Paco

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bell & Gossett

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

1. Horizontal shaft, single stage, single or double suction, split casing, 175 psig working pressure at operating temperature of 225°F continuous, 250°F intermittent.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw and protected by a replaceable bronze shaft sleeve.
3. Pump Shaft: Alloy steel with copper, bronze, or stainless-steel shaft sleeve.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. 225°F maximum continuous operating temperature.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Oil or Grease-lubricated ball or roller bearings in cast-iron housing with grease fittings.
7. Baseplate: Cast iron or fabricated steel with integral drain rim.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Single speed, secured to mounting frame, with adjustable alignment.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Open, dripproof or totally enclosed, fan cooled.

I. Capacities and Characteristics: Per the schedules on drawings.

2.2 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.
7. Supplied by pump manufacturer.

2.3 In-line Circulator:

A. Refer to “Solar Hot Water Pumps” for the in-line circulator pumps as specified in Section 235613 "Solar Water Heating Equipment.” Drawings indicate general arrangement of in-line circulator, piping, fittings, and specialties.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine inertia bases for suitable conditions where pumps are to be installed. Refer to section 230548 – “Vibration Controls for HVAC.”

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Install all pumps in strict accordance with manufacturer's instructions. Access/service space around pumps shall not be less than minimum space recommended by pump manufacturer. Comply with HI 1.4

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping

D. Set base mounted pumps on concrete bases, or concrete inertia base, level and bolt down prior to grouting. Fill the entire base with non-shrinking grout when required by the manufacturer's installation instructions.

E. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases.

1. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.

1. Comply with requirements for restraint devices specified in Section 230548 "Vibration Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

A. Perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance. Support piping adjacent to pump such that no weight is carried on pump casings.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install suction diffuser and shutoff valve on suction side of base-mounted pumps. Install Y-type strainer and shutoff valve on suction side of in-line pumps.

F. Decrease from line size at pump connections with suction diffusers where specified, long radius reducing elbows or concentric reducers/increasers in the vertical piping, and eccentric reducers/increasers for horizontal piping. Install eccentric reducers/increasers with the top of the pipe level

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

I. All valves and piping specialties must be full line size as indicated on the drawings.

J. Install a full line size spring loaded check valve and balancing valve in the pump discharge piping. At contractor's option, combination shut-off, check, balancing valve may be substituted instead of separate valves. Reference section 23 05 23.

K. Provide supports under elbows on pump suction and discharge line sizes 4 inches and over.

L. Provide drains for bases and stuffing boxes piped to and discharging into floor drains.

M. Provide air cock and drain connection on horizontal pump casings.

N. Threaded piping may be connected to flanged pumps with a threaded/flanged valves equal to Webstone "The Isolator" uni-flange ball valve.

O. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

P. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. 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. Lubricate pumps before startup.
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. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation are non-overloading in parallel or individual operation.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 23 21 23

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SECTION 23 23 00

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 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.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Filter dryers.
4. Strainers.
5. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual 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.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 for "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L and ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. 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. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

B. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.

3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

C. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

D. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

E. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. End Connections: Socket, flare, or threaded union.
6. Working Pressure Rating: 700 psig.

F. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

G. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

H. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.

5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

I. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

J. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

2.3 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with soldered joints.

B. Suction Lines NPS 2 to NPS 3-1/2 for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 5/8 and Smaller: Copper, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.
2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.

3. NPS 1-1/4 and Smaller: Copper, Type K, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. NPS 1-1/2 to NPS 2: Copper, Type K, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

D. Safety-Relief-Valve Discharge Piping:

1. NPS 5/8 and Smaller: Copper, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.
2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.
3. NPS 1-1/4 and Smaller: Copper, Type K, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. NPS 1-1/2 to NPS 2: Copper, Type K, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

B. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

C. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

D. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Compressor.

E. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

F. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements. 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. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

M. Install access doors or panels as specified in Division 08 for "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal suction lines with a uniform slope downward to compressor.
2. Install traps and double risers to entrain oil in vertical runs.
3. Liquid lines may be installed level.

P. 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.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common work Results for HVAC."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common work Results for HVAC."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. 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.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. 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 Part 1 "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Verify that compressor oil level is correct.
2. Open compressor suction and discharge valves.
3. Open refrigerant valves except bypass valves that are used for other purposes.
4. 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 25 13

WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:

1. Manual chemical-feed equipment.
2. Chemicals.

B. Related Requirements:

1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water softeners, RO equipment, and filtration equipment.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

B. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. Inhibitors.
3. TSS controllers.
4. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
2. Water Analysis: Illustrate water quality available at Project site.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, glycol fill pump, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.8 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 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. Barclay Water Management, Inc.
2. DuBois.
3. Fremont Industries
4. H-O-H Water Technology, Inc.
5. IWM Corporation
6. Mitco.
7. Morr.
8. Nalco; an Ecolab company.
9. Watertech of America, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating and glycol solution, shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 > ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 > organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 > organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero > organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero> organisms/mL.

10. System Inhibitor:

    a. Scale and corrosion inhibitor consisting of boron nitrite, benzol thiazol, benzotriazole, mercapto-benzo-thiazole, and tolyltrizole silicates.
    b. Provide and install NALCO 2837 or ArcticTherm 1015 inhibitor and shall be compatible with the proposed glycol solution to be used.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 5 gal.
2. Minimum Working Pressure: 125 psig.

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

2.5 GLYCOL WATER TREATMENT

A. Acceptable Manufacturers:

1. Dow Chemical.
2. Union Carbide UCATHERM.
3. Texaco P.G.
4. Interstate Chemical

B. The water shall meet manufacturer's requirements. Factory premix of virgin glycol water, inhibitor, colored dyed and de-ionized water solution in a 55 gallon polyethylene drum to a concentration of % by volume as listed below. Use distilled water to make the solution. Glycol shall include corrosion inhibitors and stability compounds.

C. Mix treated propylene glycol with water in ratio of glycol by volume for the following systems: Inhibited propylene glycol based material specifically designed for use in closed heat transfer systems.

1. Hot Water Systems - 30% propylene glycol.
2. Solar Heating System – 50% propylene glycol.

2.6 GLYCOL FEED SYSTEM

A. Acceptable Manufacturers:

1. Bell & Gossett, a Xylem Brand.
2. Nepture Chemical Pump Co.
3. The John Wood Company
4. Skidmore
5. Wessels Co.

B. Provide a floor mounted packaged glycol feed system that is pre-wired and pre-plumbed, and includes a storage tank, control panel, controls, pump, piping, and valves, all supported on a steel frame .

C. Provide a 50-gallon minimum translucent high density polypropylene single wall chemical mixing tank polypropylene half-lid cover. Minimum ¼ inch thick walls.

D. Provide a bronze gear pump, 120 V, single phase, and rated for a minimum of 1.5 gpm at 90 psig. Fill pump to be capable of 5 to 10 GPM at 10 psig fill pressure.

E. Y-strainer. Pump discharge shall include silent check valve, pressure switch, pressure gauge, and 150 psi relief valve piped back to tank. All piping shall be Type L Copper. Connect pump suction and discharge with braided stainless steel or bronze flex connectors. All piping, valves and accessories shall conform to Related Sections.

F. Provide a NEMA 4X control panel with 8 foot, 120 V grounded power cord. Equip the panel with motor starter, 2-position main power switch with light, hand /off/ auto switch with light for gear pump, low level red light, low level audible alarm with push button silence switch, dry contacts for remote monitoring of alarm, and a 15 amp fuse.

G. Provide electrical components that conform to Division 26 requirements. Provide all wiring in conduit. Loose, exposed or unprotected wire is not acceptable

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Level and anchor Glycol Feed System and floor-mounting accessories to substrate. Support all piping and conduits independent of the Glycol Feed Unit.

B. Install water testing equipment on wall near water chemical application equipment.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

E. Bypass Feeders: Install in closed hydronic systems, including hot-water heating and glycol solution and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
3. Install a swing check on the inlet after the isolation valve.

F. Glycol Water Systems:

1. The hot water and solar heating system are a glycol water system.
2. Add cleaner to the system water until the M alkalinity value is 250 above that of the initial fill water. Verify the M alkalinity level before and after the addition of the cleaner by means of chemical tests that are observed by the Owner's construction representative; include results of all tests in the Operating and Maintenance manuals.
3. Complete drainage by measuring amount of water used for the initial fill versus the amount actually drained to assure complete removal of the cleaning solution. Remove all traces of chloride from the system; test to verify this removal and submit test results.
4. Completely flush all traces of cleaning chemicals before adding the glycol water mixture to the system. Verify this by chemical test.
5. Refill with clean water and repeat until the system cleaner is removed and the M alkalinity level returns to normal. Remove and clean all strainers. Re-vent the system and install clean filter elements in water filters. Treat with scale and corrosion inhibitors before using the system for building heating.
6. Apply heat while circulating, slowly raising temperature to 160°F and maintain for 12 hours minimum; vent all high points to assure 100% system circulation. Remove heat and circulate to 100°F or less; drain system as quickly as possible and refill with clean water. Circulate for 6 hours at design temperature, vent air at all high points, then drain.
7. Circulate fluid for several hours, vent all high points where air may collect, add more solution to the system if needed, and test the system for proper concentration of glycol; include copy of test report in the Operating and Maintenance manuals.
8. Use a hand pump to fill system from the mixing tank for any additional glycol solution for make-up of system.

3.3 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties."

C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.

2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced glycol piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. At eight-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment. Provide 2 hours training minimum.

C. Provide site inspection of equipment during scheduled shutdown to evaluate success of the treatment program. Make recommendations in writing based on these inspections.

D. Sample glycol at substantial completion and at the end of the one-year warranty and have contractor adjust as needed.

END OF SECTION 23 25 13

SECTION 23 25 33

HVAC MAKEUP-WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended ina the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

B. Shop Drawings: Filtration equipment, maintenance space required, and piping connections to HVAC systems.

1. Include plans, elevations, sections, and attachment details.

1.4 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Other Informational Submittals:

1. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water filtration units to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 BAG-TYPE FILTERS

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. Cycron Corporation.
2. Eden Equipment Company.
3. Filter Specialists, Inc.
4. Filtration Systems; a division of Mechanical Mfg. Corporation.
5. Hayward Flow Control Systems, Inc.

6. Parker Hannifin Corp.; Process Filtration Div.
7. Pentair, Inc.
8. PEP Filters, Inc.
9. RainSoft; a division of Aquion Water Treatment Products.
10. Rosedale Products, Inc.
11. RPA Process Technologies.
12. Shelco Filters.
13. Siemens Water Technologies.

B. Description: Floor-mounting housing with filter bags for removing particles from water.

1. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through bag-type water filter; with bag support and base, feet, or skirt.

    a. Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
    b. Steel Housing Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.

2. Bag: Replaceable; of shape to fit housing.

C. Capacities and Characteristics: Refer to Schedule on Drawings.

1. Filter Design:

    a. Water Flow Rate: Refer to Schedule on Drawings.
    b. Filtration Efficiency: 98
    c. Particle Size: 25 microns and larger.
    d. Clean Pressure Loss: 2 psig.
    e. Pressure Loss at Replacement: 6 psig.

2. Housing:

    a. Material: Carbon steel.
    b. Pressure Rating: 150 psig.
    c. Seal Material: Nitrile rubber.
    d. Diameter: Refer to Schedule on Drawings.
    e. Height or Length: Refer to Schedule on Drawings.
    f. Inlet and Outlet Size: Refer to Schedule on Drawings.
    g. Drain Size: Refer to Schedule on Drawings.
    h. Bag Support Basket Material: Stainless steel.

3. Bag:

    a. Number Required: Box – Qty 20 Bags.
    b. Media Material: Polyester Bags.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water filtration equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water filtration equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing.
3. Place HVAC water filtration system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Periodic field service and consultation.
2. Customer report charts and log sheets.
3. Laboratory technical analysis.
4. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 23 25 33

SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Delegated Process Duct Design: Duct construction for process room ducts, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with the process duct schedule on the drawings, SMACNA's latest version of "Round Industrial Duct Construction Standards", and SMACNA's latest version of "Rectangular industrial Duct Construction Standards".

1. Exception: Weld penetration shall be 100% for all process duct welds.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Indicated duct sizes are inside clear dimensions.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. 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 of ducts.
5. Dimensions of main 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.

D. Delegated-Design Submittal:

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, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

1.4 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 D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Construct all ductwork to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions. Objectionable conditions shall be corrected to the satisfaction of the [Owner] [Contracting Officer], at no cost to the Contract.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Duct Joints for Stainless Steel Ducts:

1. All sizes: Welded longitudinal seam joint construction.

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Sheet Metal Connectors, Inc.
e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Duct Joints for Stainless Steel Ducts:

1. All sizes: Welded longitudinal seam joint construction.

2.3 SHEET METAL MATERIALS

A. See drawing schedule for sheet metal material requirements

B. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

H. Tie Rods: Galvanized steel, 1/4-inchminimum diameter for lengths 36 inches or less; 3/8-inchminimum diameter for lengths longer than 36 inches.

I. Provide paint grip type ductwork where ductwork is exposed and indicated to be painted.

J. Double-Tee Pan Ductwork: Where indicated on drawings, enclose the space between two double-tee stems with minimum 20 gauge, No. 4 finish. 1" thick insulated galvanized steel panels. Every 5'-0" o.c., there shall be a 1½" x 20 ga. standing seam joint.

1. See double-tee stem enclosure detail on drawings.
2. Insulation shall be polyisocyanurate or polystyrene

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

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. CertainTeed Corporation; Insulation Group.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.

2. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
4. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

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. Aeroflex USA Inc.
    b. Armacell LLC.
    c. Rubatex International, LLC

2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

    a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. 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.

D. 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.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

H. Wet Areas: Sealant: Equal to clear G.E. Silicone Series 1200 caulk.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

I. All hangers and supports shall be smooth stainless steel in wet areas. Stainless steel type shall match ductwork being supported.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

1. Where ductwork passes through walls, floors, or ceilings of finished rooms, provide stainless steel flange around penetration.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Ductwork sleeves shall be formed with galvanized steel.

N. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

O. At ends of ducts not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering until time connections to be completed.

P. Sizing Variation: Round ducts may be installed in place of rectangular ducts and rectangular ducts may be installed in place of round ducts using equivalency tables from ASHRAE or SMACNA. No variation of duct configuration or sizes permitted except by written permission from Engineer.

Q. Drain Pockets:

1. Provide form drain pocket in outdoor air, dishwasher exhaust, any duct carrying high-moisture air, and humidifier sections with deep seal traps.
2. Connect to drainage system.

R. Provide expanded take-offs for branch duct connections or 45 degree entry fittings. Square edge 90 degree take-off fittings or straight taps will not be accepted

S. Size Change:

1. Increase and decrease duct sizes gradually, not exceeding 20 degrees divergence and 30 degrees convergence from connecting upstream duct surface, unless otherwise noted on drawings.
2. Maximum divergence upstream of equipment to be 20 degrees and maximum convergence downstream to be 30 degrees.

T. Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

1. Where ductwork passes through walls, floors, or ceilings of finished process rooms, provide stainless steel flange around penetration.

U. Install duct to pitch as indicated on the drawings.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. See drawing schedule for duct sealing requirements.

B. Install duct to pitch toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.

C. Fabricate seams and joints liquid-tight with continuous exterior welds or gasketed, bolted flanged connections in following locations:

1. Kitchen or other high-grease content.
2. Dishwasher or other high-moisture content.
3. Shower rooms.
4. Lower 6 inches of horizontal outdoor air ducts.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

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 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.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Engineer from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

D. Duct system will be considered defective if it does not pass tests and inspections.

3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. 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.

D. 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.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. See drawing schedule for duct pressure, seal and leakage class, and elbow configuration.

B. 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.

3. Aluminum Ducts: Aluminum.

C. Liner:

1. Supply Air Ducts: Fibrous glass, Type I or Flexible elastomeric, 1 inch thickness thick.
2. Transfer Ducts: Fibrous glass, Type I or Flexible elastomeric, 1inch thickness thick.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Velocity 1000 fpm or Lower:

      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.

   b. Velocity 1000 to 1500 fpm:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

   c. Velocity 1500 fpm or Higher:

      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.

   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13

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SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

2. 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.
e. Wiring Diagrams: For power, signal, and control wiring.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Air Balance Inc.; a division of Mestek, Inc.
    b. American Warming and Ventilating; a division of Mestek, Inc.
    c. Flexmaster U.S.A., Inc.
    d. McGill AirFlow LLC.
    e. Nailor Industries Inc.
    f. Pottorff.
    g. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Frame: Hat-shaped, 0.094-inch-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. Stiffen damper blades for stability.
    d. Galvanized or Stainless-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.

7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Air Balance Inc.; a division of Mestek, Inc.
    b. American Warming and Ventilating; a division of Mestek, Inc.
    c. McGill AirFlow LLC.
    d. Nailor Industries Inc.
    e. Pottorff.
    f. Ruskin Company.
    g. Trox USA Inc.
    h. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

6. Blade Axles: Galvanized steel or Stainless steel.
7. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

A. Control dampers are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

2.5 FIRE DAMPERS

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. Arrow United Industries; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 inch-thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

2.6 DUCT SILENCERS

A. Basis-of-Design Product: The design is based on the following:

1. Vibro-Acoustics.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Industrial Noise Control, Inc.
2. McGill AirFlow LLC.
3. VAW Silencers

C. 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 according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

E. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inch thick.

F. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

G. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.

H. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

I. Connection Sizes: Match connecting ductwork unless otherwise indicated.

J. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative type with fill material.

    a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression
    b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

K. 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.

1. Joints: Flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

L. Source Quality Control: Test according to ASTM E 477.

M. Capacities and Characteristics: Refer to Schedule on drawings.

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Elgen Manufacturing.
3. METALAIRE, Inc.
4. SEMCO Incorporated.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

    a. Double wall, rectangular.
    b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    c. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
    d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
    c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches.
    d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Elgen Manufacturing.
3. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 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.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.10 FLEXIBLE DUCTS

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. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.

B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

C. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

D. Flexible Duct Connectors:

1. Clamps: Nylon strap in sizes 3 through 18 inches, to suit duct size.
2. Non-Clamp Connectors: Liquid adhesive plus tape.

E. Flexible Ductwork Elbow Supports:

1. Available Manufacturers:

a. Thermaflex: Flexflow Elbow

2. In lieu of using die stamped elbows for flexible duct connections to supply air diffusers (as detailed on the drawings), the Contractor may delete the die stamped elbow and directly connect the flexible duct to the diffusers with the use of a flexible ductwork elbow support.
3. Elbow supports shall be constructed of durable composite material and shall be fully adjustable to support flexible ductwork diameter from 6" to 16" in diameter.
4. Elbow supports shall be in UL listed for use in return air plenums.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," 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. 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.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing.

H. Connect ducts to duct silencers rigidly.

I. 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 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.
7. Control devices requiring inspection.

8. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. 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.

L. Access door size shall be 12 inches by 12 inches unless specified otherwise.

M. Label access doors according to Section 230553 "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-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect diffusers to ducts directly or with maximum 36-inch lengths of flexible duct clamped or strapped in place.

Q. Install duct test holes where required for testing and balancing purposes.

R. 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.

S. Access doors constructed with sheet metal screw fasteners will not be accepted

T. Flexible Ductwork:

1. Do not exceed 3 feet in length. Flexible ducts shall be used only to compensate for branch duct and diffuser/grille misalignment. No kinks or bends shall be allowed.
2. Install flexible ductwork with minimum offsets, sag, and trim.
3. Connect with adjustable band and clamp to secure duct to trunk fitting and to distribution unit fitting. Banding shall be nylon straps, fastened under insulation and over the inner lines with a second band securing the insulation and jacket. Sheet metal screws will not be accepted.
4. Seal ends of flex duct with foil duct tape over insulation and jacket.
5. Individual sections of flexible ductwork shall be of one piece construction. Splicing of short sections will not be accepted.
6. Penetration of any partition, wall, or floor with flexible duct will not be accepted.
7. Minimum length of duct trunk fitting for flex duct connection shall be 4 inches.

U. Fire dampers shall be installed where and when necessary, whether or not indicated on drawings, in compliance with all applicable local, state and insurance codes and requirements, and other authorities having jurisdiction.

V. Manually test each fire damper for proper operation by removing the fusible link. Repair or replace any fire damper that does not close completely. Re-install fusible link after test.

W. Demonstrate re-setting of fire dampers to Commissioning Agent.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories. Include plans, elevations, sections, details, and attachments to other work

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SUPPLY AIR VALVES

A. Factory calibrated, pressure independent vortex shedding or venture type valve for constant volume or variable volume applications.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Tek-Air Accutrol, LLC Model: Accu-Valve

2. Price Critical Controls

C. Supply Construction: Valve body and cone shall be 16 gauge spun aluminum or 316 stainless steel with internal components of aluminum or stainless steel. Valve body ends shall have slip connections. Control valve shall be mounted to a 316 stainless steel shaft on teflon bearings.

D. The pressure independent shall be electronic pressure or spring shall be stainless steel.

E. Valve shall be air-based valve which measures airflow measures airflow directly and will drive the valve blades to achieve the required airflow regardless of the pressure in the system.

F. Performance: Valve shall be pressure independent with vortex airflow sensing or venturi for high turndown. Vortex baffle or calibrated spring shall maintain a cfm setting within +/- 5% over a calibrated range of .3 – 3.0 inches w.c. duct pressure range. Valve shall be capable of 16:1 turndown ratio. Valve shall be capable of 100% shutoff where noted on the drawings.

G. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230900 "Instrumentation and Control for HVAC."

2.3 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: Galvanized steel complying with ASTM A 603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units as indicated on project drawings and in accordance with the manufacturer’s installation instructions.

B. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

D. Units shall be suspended from building structure. Units shall not be mounted to adjacent piping or ductwork. Fan powered units shall be suspended by vibration isolator hangers.

E. Provide at least 24” of clearance on controller side of the air terminal unit. The clearance area shall extend the full length of the supply air terminal unit and the full length (including the access door) of the supply air terminal unit

3.2 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 and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. 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.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Connect ducts to air terminal units according to Section 233113 "Metal Ducts."

C. Provide a minimum three (3) duct diameter straight length of rigid duct to air terminal inlet. Match inlet duct diameter with air terminal inlet collar diameter. Flexible duct connection to air terminal inlet collar will not be permitted.

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
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. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 ADJUSTING

1. Coordinate adjustment of air terminal units with section 230593 - Testing, Adjusting and Balancing.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 00

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.3 INFORMATIONAL SUBMITTALS

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Krueger.
b. METALAIRE, Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus.
f. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: See Air Outlets and Inlets Schedule on drawings.
4. Finish: See Air Outlets and Inlets Schedule on drawings.
5. Face Size: See Air Outlets and Inlets Schedule on drawings.
6. Face Style: See Air Outlets and Inlets Schedule on drawings.
7. Mounting: See Air Outlets and Inlets Schedule on drawings.
8. Pattern: Fixed.
9. Dampers: See Air Outlets and Inlets Schedule on drawings.

2.2 HIGH-CAPACITY DIFFUSERS

A. Sidewall Adjustable Bar Grille:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Krueger.
b. METALAIRE, Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus.
f. Tuttle & Bailey.

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Frame: See Air Outlets and Inlets Schedule on drawings.
5. Mounting: See Air Outlets and Inlets Schedule on drawings.

2.3 REGISTERS AND GRILLES

A. Ceiling Adjustable Bar Grille:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Krueger.
b. METALAIRE, Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus.
f. Tuttle & Bailey.

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Frame: See Air Outlets and Inlets Schedule on drawings.
5. Mounting: See Air Outlets and Inlets Schedule on drawings.

B. Ceiling Fixed Face Grille:

1. Manufacturers: Subject to compliance with requirements.

a. Krueger.
b. Nailor Industries Inc.
c. Price Industries.
d. Titus.
e. Tuttle & Bailey.

2. Material: See Air Outlets and Inlets Schedule on drawings.
3. Finish: See Air Outlets and Inlets Schedule on drawings.
4. Face Arrangement: See Air Outlets and Inlets Schedule on drawings.
5. Core Construction: See Air Outlets and Inlets Schedule on drawings.
6. Frame: See Air Outlets and Inlets Schedule on drawings.
7. Mounting:See Air Outlets and Inlets Schedule on drawings

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

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SECTION 23 41 00

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. 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.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

D. Supply all filters from one manufacturer, unless indicated otherwise.

E. Assemble filter components to form filter banks from one manufacturer.

F. Filter frames and supports structures shall be fabricated by equipment manufacturers.

PART 2 - PRODUCTS

2.1 FLAT PANEL FILTERS

A. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AAF International.
b. Camfil Farr.
c. Filtration Group.
d. Flanders-Precisionaire.
e. Research Products Corp.

B. Filter Unit Class: UL 900, Class 1.

C. Media: 1 inch Interlaced glass or synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.
3. Metal Retainer: Upstream side and downstream side.

D. Filter-Media Frame: Cardboard with perforated metal retainer sealed or bonded to the media on the air leaving side.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics: Refer to Schedules on drawings.

2.2 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AAF International.
b. Airguard.
c. Camfil Farr.
d. Filtration Group.
e. Flanders-Precisionaire.
f. Research Products Corp.

B. Filter Unit Class: UL 900.

C. Media: 4-inch Interlaced glass or 100% synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.
3. Separators shall be bonded to the media to maintain pleat configuration.
4. Welded wire grid shall be on downstream side to maintain pleat.
5. Media shall be bonded to frame to prevent air bypass.
6. Support members on upstream and downstream sides to maintain pleat spacing.

D. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. Thickness or Depth: 4 inches.
2. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
3. Arrestance: 85 percent when tested according to ASHRAE 52.1.
4. Initial Resistance: 0.35-inch wg at 500 fpm.
5. Recommended Final Resistance: 1.0 inches wg.
6. MERV Rating: 8 when tested according to ASHRAE 52.2.

2.3 HOUSINGS FOR PANEL FILTERS

A. Manufactured by air handling unit manufacturer, filter media manufacturer, or contractor fabricated. Casing and tracks constructed of galvanized or enameled steel or aluminum. Provide access to the media tracks from outside the casing so media and be readily changed.

2.4 HOUSINGS FOR MERV 8 FILTERS

A. Housing or holding frame to be of the same manufacturer as filter media or provided by 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. Provide access to the media tracks from outside the casing so media and be readily changed. Filter tracks shall be constructed to provide a minimum clearance of 2 inches between the pre-filter and final-filter media to facilitate the installation of static pressure tips.

2.5 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel with flanges to connect to duct or casing system. Mounting tracks and access doors to have gaskets to minimize air bypass around the filters. Housing assembly to be suitable for use in duct systems with 6-inches of water static pressure.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AAF International.
b. Camfil Farr.
c. Continental
d. Filtration Group.
e. Flanders-Precisionaire.
f. Research Products Corp.

B. Prefilters: Integral tracks to accommodate 2-inch-deep, disposable filters.

C. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door. Furnish housings for MERV 13 with a lever action sealing mechanism to secure media in tracks.

D. Standard filter sections provided by air handling unit manufacturers may be used.

E. Insulate housings where adjacent duct or air handling apparatus is insulated. Insulation to be contained within a 2" thick, double wall steel panel and meet the requirements specified for adjacent duct or apparatus.

F. Furnish a door on each end of the housing to facilitate filter changing. Doors to be hinged and provided with lever handle latches to secure the door. Doors shall not be secured with nuts, bolts, wing nuts, or sheet metal screws.

G. Filter bypass shall be less than 5% of design cfm

H. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

I. Filter tracks shall be constructed to provide a minimum clearance of 2 inches between the pre-filter and final-filter media to facilitate the installation of static pressure tips

2.6 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Airguard.
   b. Dwyer Instruments, Inc.

2. Diameter: 4-1/2 inches.
3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.
4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.

B. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

2.7 MEDIUM EFFICIENCY FILTERS

A. Available Manufacturers:

1. AAF International: Varicel SH
2. Cambridge Filter Corp:
3. Camfil Farr Co.: Riga-Flo
4. Filtration Group: Aerostar

B. Media: 12" deep extended surface supported pleat, ultrafine fiberglass dual density media supported on corrugated aluminum separators, U.L. Class 1.

C. Frame: Galvanized steel single header and frame with horizontal bar brace.

D. Performance: MERV 13. 80-85% average efficiency. Initial resistance of 0.50 inches W.G. at 500 FPM.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate. Reinforce filter holding frames per manufacturer's instructions.

B. Where air handling equipment is to be used for temporary heating or ventilation of a facility, do not operate the equipment until specified filter media has been installed. Contractor shall be responsible for maintaining the cleanliness of air handling apparatus and air distribution systems during construction through regular inspection and changing of filter media throughout the construction period.

C. Where air handling apparatus is used during the construction period, install new filter media prior to start of air balancing. Additionally, deliver one new set of media to the owner prior to substantial completion.

D. Install units as shown on drawings and details according to manufacturer's instructions.

E. Install filters in position to prevent passage of unfiltered air.

F. Install filter gage for each filter bank.

G. 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.

H. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages. Install tubing and gauge valves between gauge and sensor tips.

I. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

B. Air filter will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Operate installed air filters and housings to demonstrate compliance with specifications.

E. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.

F. DO NOT operate fan systems connected to filter banks until filters (temporary or permanent) are in place. Replace filters used during construction. Install new filters at substantial completion.

3.3 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 00

BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:
1. Special gas vents.

B. Shop Drawings: For vents and breechings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
2. Submit manufacturer's installation instructions including required clearance to combustible materials.

1.3 INFORMATIONAL SUBMITTALS

A. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

1.5 DESIGN CRITERIA

A. Follow the requirements of NFPA 211 and State codes.

1.6 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 EXHAUST VENTS FOR CONDENSING APPLIANCES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Heat-Fab, Inc.
2. Metal-Fab, Inc.
3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Exit cone with drain section incorporated into riser.
3. Sealant: Manufacturer's standard high-temperature sealant.
4. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.
5. Size exhaust vents in strict accordance with appliance manufacturer's requirements.

2.2 COMBUSTION AIR VENTS FOR CONDENSING APPLIANCES

A. Provide combustion air vents, fittings, and accessories constructed of schedule 40 CPVC where in accordance with appliance manufacturer's recommendations.

B. Size combustion air vents in strict accordance with appliance manufacturer's requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

3.4 INSTALLATION

A. Locate exhaust termination in accordance with appliance manufacturer's recommendations to prevent re-entry of products of combustion.

B. Suspend breechings independent of their appliance connections.

C. Install, support, and restrain according to manufacturer’s requirements. Install stacks plumb.

D. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch misalignment tolerance.

E. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

F. Lap joints in direction of flow.

G. Support breechings from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

H. Stack Termination:
1. Extend stack to heights above roof recommended by manufacturer for type of roofs, adjacent structures, and appliances served.
2. Termination of exhaust within 10 feet of operable windows, other building openings, or air intakes will not be accepted. Termination of exhaust vents shall be a minimum 3 feet and installed per manufacturer’s guidelines using the 2-10 Rule. The 2-10 Rule states that combustion vents should terminate at least 2 feet above any part of the roof within 10 feet.
3. Provide spark arrester and fly screen with maximum 3/4 inch openings.

I. Ensure that stack sections are properly aligned.
1. Seal sections with manufacturer's joint cement and draw bands.
2. Install with minimum of joints.
3. Provide slip joints to allow removal of appliances without removal or dismantling of exhaust vent.

J. Termination of exhaust within 10 feet of operable windows, other building openings, or air intakes will not be accepted. Termination of exhaust vents shall be a minimum 3 feet and installed per manufacturer’s guidelines using the 2-10 Rule. The 2-10 Rule states that combustion vents should terminate at least 2 feet above any part of the roof within 10 feet.

K. Support exhaust vent from building structure with suitable ties, braces, hangers and anchors to hold shape and prevent buckling. Minimum support for vertical sections shall be at roof penetrations. Support from roof structure, or adjacent structural surfaces. Verify load bearing capacity of support points. Support horizontal breeching at 8 foot intervals for sizes up to 12" diameter.

L. Seal all joints of positive pressure stacks and breeching in accordance with manufacturer's recommendations, using only sealants recommended by stack manufacturer.

3.5 COMBUSTION AIR VENTS FOR CONDENSING APPLIANCE:

A. Locate combustion air intake in accordance with appliance manufacturer's recommendations to prevent re-entry of products of combustion.

B. Pitch combustion air vents from intake down toward appliance connection.

C. At appliances, provide slip joints to allow removal of appliances without removal or dismantling of combustion air vent.

D. All joints of combustion air shall be solvent welded and leak tight. Provide drain connection at base of air combustion vent, and pipe to nearest open site drain.

3.6 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris.

C. Provide temporary closures at ends of breechings that are not completed or connected to equipment.

D. At ends of combustion air and exhaust vents which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until final connections are made.

END OF SECTION 23 51 00

SECTION 23 52 16

CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Include diagrams for power, signal, and control wiring.
2. Warranty: Special warranty specified in this Section.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil-Fired Boilers - Minimum Efficiency Requirements."

D. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Boiler shall be provided with fuel train and operating controls conforming to the latest CSD-1 requirements, and FM or IRI approval.

F. Comply with State of Wisconsin boiler codes and regulations.

G. All boiler equipment, trim, and accessories shall be shipped factory mounted, except for items removed due to shipping clearances. All items removed for shipping shall be noted.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.6 REGISTRATION

A. Complete Boiler and Unfired Pressure Vessel (UPV) Installation Registration and forward to the Department of Safety and Professional Services in accordance with the Wisconsin Administrative Code Chapter SPS 341.24.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Fire-Tube Condensing Boilers:

      a. Leakage and Materials: Ten (10) years from date of Substantial Completion.
      b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five (5) years from date of Substantial Completion.
      c. All other boiler, burner and control parts warranted for one year from startup.

   2. Sealed combustion boiler, condensing, hi-efficiency, (modular,) helical heat exchanger/combustion chamber design that will be self-supporting, and warranted for a period of 10 years to withstand thermal shock. Heat exchanger shall be warranted against leakage for a period of 10 years.

PART 2 - PRODUCTS

2.1 STAINLESS STEEL, FIRE-TUBE CONDENSING BOILERS

A. Manufacturer Basis-of-Design Product: The design is based on the following:

   1. Lochivar Crest

B. Manufacturers: Subject to compliance with requirements, provide the named product or a comparable product by one the following:

   1. AERCO International – Benchmark.
   2. Viessmann - 300CA3

C. Provide units with capacity and operating characteristics indicated on schedules.

D. Description: Factory-fabricated, assembled, and tested, fire-tube hi-efficiency condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

E. Single pass firetube boiler with stainless tubes & tubesheet. No minimum return water temperature, and or minimum water flow required for proper operation. Boiler ASME H stamped and constructed for 125 psig and designed per ASME section IV. Furnish a relief valve in compliance with ASME section IV, and set at 50 psig.

F. Heat Exchanger: All internal combustion chamber, and internal burner components, shall be manufactured with stainless steel materials suitable to withstand constant operation under condensing conditions. Combustion chamber shall have a condensate drain to discharge any condensate buildup. CSA certified as an indirect or direct vent boiler and comply with ASME CSD-1

G. Boiler minimum efficiency of 94%+ per BTS 2000, and operation in the condensing mode with inlet temperatures as low as 90 F.

H. Combustion air intake capable of accepting direct outside air through a sealed intake pipe. Provide inlet/outlet combustion vent temperature fittings with direct outside air application.

I. Category II, III, or IV flu vent connection as appropriate for installation, for vertical, horizontal and sidewall venting. The vent outlet shall be compatible with installation.

J. Pressure Vessel: Carbon steel with welded heads and tube connections.

K. Burner: Natural gas, forced draft.

L. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. 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.

M. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Natural gas-fired burners, forced draft power type with a positive pressure at the boiler discharge. Stainless steel burner mixer or Alloy Fiber. Maximum Nox emissions under 20 PPM. Pre-mix design to allow modulation of fuel and air for a minimum of 5:1 turndown.

N. Furnish units with fuel trains and operating controls conforming to the latest UL or equivalent agency approval, ASME CSD-1 requirements, Boiler/burner package shall be factory assembled, wired, mounted, and factory fire tested.

O. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

P. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures. Removable panels.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel or Powder-coated or Stainless-steel protective finish.
4. Insulation: Minimum 2-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.
6. Mounting base to secure boiler.

2.2 TRIM

A. Aquastat Controllers: Operating and high limit.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gage: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

D. Boiler Air Vent: Automatic.

E. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

F. Inlet and outlet temperature gauge to monitor and limit inlet and outlet water temperatures.

G. Pressure gauge mounted on water outlet.

H. Omit controller if sequencing panel or external control will be used.

I. Provide a water temperature controller.

J. Provide each boiler with a low water cutout operationally testable, manually reset on loss of low-water and auto-rest on loss of power in accordance with ASME Section IV and CSD-1.

K. Provide each boiler with dual over temperature protection, including manual reset, in accordance with ASME Section IV and CSD-1.

L. Provide remote fault alarm contact for flame sensor and high temperature limit failure.

2.3 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

B. Refer to Specification Section 230993 and mechanical drawings Series M800 for hot water system operation including boiler and primary pumps.

C. Provide a Boiler controller with capability of burner sequencing, flame supervision, safety shutdown, burner modulation control, gas pressure supervision, combustion air proving, pump control,

D. Boiler management system (sequencing panel) may be specified in addition to integral boiler controls for multiply boiler projects. The following paragraph must be modified to individual project needs and coordinated with temperature control specification sections.

E. Provide a multiple boiler sequencing panel (BMS) or integral boiler controller capable of staging boilers to maintain peak seasonal efficiency. BMS shall include a sensor to monitor main loop system temperature, and a sensor to monitor outside air temperature. BMS shall be capable of outdoor reset, loop temperature span, and set loop temperature. BMS shall have the capability to stage boilers based on loop temperature and outdoor reset for highest operating seasonal efficiencies. BMS shall be capable of starting and stopping the system based on a remote contact closure and have the ability to change set-point from a remote location. Manufactures: Honeywell, Heat Timer, Techmar, or equivalent.

F. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.

G. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

H. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

a. Monitoring: On/off status, common trouble alarm, low water level alarm.
b. Control: On/off operation, hot water supply temperature set-point adjustment.

2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

I. Provide controls to allow system enable/disable and general alarm via binary input and output from the existing control system. Provide all required interface hardware and software required for a BACnet MSTP interface connection to the DDC system. Interface shall be a multi-protocol, communications gateway to support integration with building automation system. Interface captures alarm and trend history of boilers

J. A list of standard control points for each category of equipment includes set point, fire rate, outlet temperature, unit status, run cycles and run hours.

2.4 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, fan and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color-coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall a fused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker capable of being locked in the open position at an accessible location at the boiler; integral or adjacent to the boiler.
6. Provide each motor with overcurrent protection.
7. Provide a manually operated remote emergency shutdown switch or circuit breaker just outside the boiler room door and mark for easy identification.

2.5 VENTING KITS

A. Refer to Section 235100 for “Breeching, Chimney and Stacks” for exhaust and combustion air venting installation.

B. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

C. Combustion-Air Intake: Complete system, schedule 40 CPVC pipe, vent terminal with screen, inlet air coupling, and sealant.

D. Verify air pipe sizes shown on drawings with boiler manufacturer to ensure pipe is large enough to accommodate length of pipe and number of fittings in system.

2.6 NEUTRALIZATION KIT

A. A. Provide an acid neutralization kit for condensate out of boiler and stack for condensing type boiler.

B. An acid neutralization kit for condensing boilers as it will produce condensate as heat is transferred from the flue produces into the heat exchanger. This condensate will have a pH imbalance of 2 or 3 pH. The condensate shall be returned to a relatively normal pH level. Neutralizing kit shall bring the condensate back to a pH level near 7 pH. Contractor shall pipe per manufacturer’s recommendations.

2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

F. Flush, cure, and thoroughly clean boilers and boiler accessories upon completion of installation and prior to start-up in accordance with boiler manufacturer's instruction.

G. After piping system has been flushed, boil out boilers using chemical and procedure as recommended by boiler manufacturer. Perform boil-out under supervision of boiler manufacturer's representative.

H. Manufacturer shall verify in writing that boilers have been cleaned according to their recommendations and are ready for operation.

I. Isolate boilers from piping system during boil-out. Owner's representative and/or Engineer will observe boil-out. Contractor must notify Engineer at least 72 hours prior to boil-out.

J. Install all items shipped loose by equipment manufacturer under supervision of equipment manufacturer's field service personnel.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer, if required.

F. Install gas pressure gauges at downstream of gas pressure regulators.

G. Pipe vents from gas train to atmosphere. Size of each vent shall not be less than connection size to device.

H. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

I. Install piping from safety relief valves to nearest floor drain.

J. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections.
3. Refer to Section 235100 for “Breeching, Chimney and Stacks” for exhaust and combustion air venting installation

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

M. If remote control panels are used, install all interconnecting wiring and pneumatic tubing if used between panels and units.

N. Connect condensate drain lines from the boiler and flue to the neutralizing basin and flue gas trap and routed to the nearest floor drain.

O. The condensate drain lines from the boiler and flue to the neutralizing basin will be piped with polypropylene or schedule 80 PVC designed for acidic applications. The pipe downstream of the neutralizing basin can be any material allowed by Division 22 for drains.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

E. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Engineer in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training." Provide a minimum period of 4 hours.

END OF SECTION 23 52 16

SECTION 23 56 13

SOLAR WATER HEATING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hot Water Solar Collector Panels (Provided by Owner)
2. Solar Hot Water Storage Tank
3. In-tank Water-Water Heat Exchangers
4. Solar Hot Water Pumps
5. Solar Hot Water Expansion Tank
6. Solar Hot Water Glycol Fill Tank
7. Pipe and fittings

1.3 DEFINITIONS

A. HI – Hydronics Institute

B. NABCEP: North America Board of Certified Energy Practitioners

C. SRCC: Solar Rating and Certification Corporation.

1.4 ACTION SUBMITTALS

A. Submit complete shop drawing data on solar equipment proposed including wiring and control diagrams, system schematic, performance charts and curves, installation, operation, and maintenance instructions, and other data sheets related to the solar equipment proposed.

B. Product Data: For each type of product.

1. Hot Water Solar Collector Panels (OFCI)

a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for solar collectors.
b. Include rated capacities, operating characteristics, and furnished specialties and accessories.
c. Shop Drawings: For solar collectors.

1) Include plans, elevations, sections, and mounting and attachment details including collector layout, orientation, and tilt angle.
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 wiring and control diagrams.

2. Solar Hot Water Storage Tank

   a. Include rated capacities, accessories, appurtenances, and furnished specialties
   b. Shop Drawings: Show fabrication and installation details for each solar hot water storage tank including the following:

      1) Tank and shell openings
      2) Plans, elevations, sections, and attachment details
      3) Power, signal, and control wiring diagram

3. In-tank Water-Water Heat Exchangers

   a. Include rated capacities, operating characteristics, and furnished specialties and accessories.

4. Solar Hot Water Pumps

   a. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
   b. Shop Drawings: For each pump.

      1) Show pump layout and connections.
      2) Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
      3) Include diagrams for power, signal, and control wiring.
      4) Include NPSH curve when specified.
      5) Certified dimension prints showing all necessary details of construction.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates:

1. Hot Water Solar Collector Panels:

   a. Owner Furnished, Contractor Install. (OFCI)

2. Solar Hot Water Storage Tank

   a. Qualification Data: For fabricator
   b. Welding Certificates

3. In-tank Water-Water Heat Exchanger

   a. Domestic-Water, Heat-Exchanger Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

B. Field quality-control reports.

C. Startup performance results.

1.6 QUALITY ASSURANCE

A. Solar Hot Water Storage Tank

1. Welding Qualifications: Qualify procedures and personnel according to the following:

a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
c. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

2. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."

PART 2 - PRODUCTS

2.1 Hot Water Solar Collectors (OFCI)

A. General: Owner to furnish solar collectors and support structures with the characteristics specified below. Contractor to install solar collectors and support structures as specified.

B. Performance

1. Plot thermal performance on thermal efficiency curve in accordance with ASHRAE 93 showing the product of glazing transmittance and plate absorptivity and also the thermal loss coefficient of the solar collector.
2. Show manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate.
3. Indicate the manufacturer's recommendations for the number of collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

C. Manufacturers

1. Schüco

D. Enclosure: Extruded aluminum.

E. Back Sheet: Aluminum sheet.

F. Insulation: Fiberglass board

G. Absorber Plate: Copper fins and tubes, aluminum fins and copper tubes, or copper sheet; absorptivity = 0.96, emissivity = 0.08.

H. Header and Absorber Tubes: 1-inch Type M Copper.

I. Glazing:

1. Glazing Materials: Single-sheet, low-iron, tempered glass with textured finish on outside surface; solar transmission of 90% minimum.
2. Gaskets and Grommets: UV-resistant EPDM gaskets with molded corners and extruded silicone grommets.
3. Continuous secondary silicone seal between the glass and enclosure.

J. Support Structure: Owner to furnish. Contractor to install.

1. Fabricated to withstand wind loads of up to 130 mphwith no separation of the collector from the frame or the frame from the structure.
2. Material: Stainless steel, extruded aluminum, hot dipped galvanized, primed and painted steel, or other corrosion-resistant approved material.
3. Profile: High angle, 27 to 62 degrees.
4. Fasteners and Mounting Hardware: Stainless steel.

K. Collector Certification: Certified by FSEC and SRCC.

L. Controls

1. Comply with requirements in Section 230993 "Sequence of Operations for HVAC DDC."

M. Capacities and Characteristics

1. Solar Panel Area:

   a. Gross: 29 sq. ft.
   b. Net Aperture: 27 sq. ft.

2. Dry Weight: 106 Insert lb.
3. Fluid Type: 50% Polypropylene Glycol.
4. Fluid Capacity: 0.6 gal.
5. Test Pressure: 218 psig.

N. Hail Resistance: Able to withstand 1-inch-diameter hail.

O. SRCC Certified Performance Rating:

1. Clear Day at 23100 Btu/panel per Day
2. Mildly Cloudy Day at 13400 Btu/panel per Day
3. Cloudy Day at 4600 Btu/panel per Day.

2.2 SOLAR HOT WATER STORAGE TANK

A. General: Horizontal double-wall, stainless steel or glass-lined steel pre-insulated storage tank; ASME rated complete with inlets, outlets, water level site glass, sensors, fill valves, safety relief valve, saddles, mounting hardware, and drain fittings as indicated on drawings details and schematics.

B. Manufacturers

1. Cemline
2. BadgerLand Tanks
3. Hubbell
4. Wessels
5. Niles Steel Tank Company
6. Wheeler Tank Manufacturer

C. Characteristics

1. Capacity: 800 gallons
2. Dimensions: 54 inch Diameter; 113 inch length.
3. Pre-Insulation: 2 inch R-12. See Pipe Insulation Schedule insulation type I1.
4. Pre-Jacketing: All service jacket. See Pipe Insulation Schedule jacket type J1.
5. Maximum Working Pressure: 125 psig.
6. Safety Relief Valve Pressure Setting: 50 psig.

2.3 IN-TANK WATER-WATER HEAT EXCHANGER

A. General: Factory fabricated, horizontal tank U-tube in-tank mounter, water-water heat exchanger.

B. Manufacturers:

1. Bell and Gossett

C. Heat exchanger must be constructed and stamped in accordance with ASME Boiler and Pressure Vessel Code: Section VIII.

D. In-tank water-water heat exchangers shall be of the shell and tube type. The tube bundle shall be of 'U' bend construction with tube ends expanded into a stationary tube sheet. Design shall use removeable flanged header with removable water connections to allow easy removal of heat exchanger. Mating flanged collar shall be provided to tank manufacturer and welded in place during tank construction for heat exchanger mounting in field.

1. 90/10 cupro-nickel tube construction

E. All materials, including fittings and piping, in contact with domestic water are to ne non-ferrous. Provide single or double-wall copper/nickel, inner and outer, tube water bundle(s) with nonferrous tube sheet and baffles. Provide iron header chamber flanged cover.

F. Domestic Heat-Exchanger Coil (HX-1): Single-wall, copper-nickel coils for booster heating coils and the domestic water. Include pressure rating equal to or greater than heating-fluid-supply pressure.

G. Solar Heat Heat-Exchanger Coil (HX-2): Single-wall, copper-nickel coils for solar heating hot water. Include pressure rating equal to or greater than heating-fluid-supply pressure.

2.4 SOLAR HOT WATER PUMPS

A. General: Provide factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically as indicated on drawings.

B. Refer to Hydronic Pump Schedule for capacities.

C. Manufacturer Basis-of-Design Product: The design is based on the following:

1. Grundfos Magna 3

D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bell and Gossett

E. Pump Construction:

1. Type: In-line circulating pump.
2. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet and threaded companion-flange connections.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
4. Shaft: Stainless steel with integral thrust collar.
5. Bearings: Sealed permanently lubricated ball bearings.
6. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on pump shaft between motor and seal.
7. Maximum pump rating is 230 degrees Fahrenheit.

F. Motor: Non-overloading, TEFC motor, oil-lubricated journal bearings, resilient mounted construction, built-in thermal overload protection on single phase motors.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Inline pumps shall be equipped with an ECM motor with an integral controller for constant pressure control of pump output. Refer to Hydronic Pumps Schedule for ECM motor requirements.

G. Provide circulating pumps with interface capabilities with Building Automation System.

1. Comply with requirements specified in Section 230993 "Sequence of Operations for HVAC DDC."
2. Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."

2.5 SOLAR HOT WATER EXPANSION TANK

A. Comply with requirements specified in Section 232116 “Hydronic Piping Specialties”

2.6 Solar Hot Water Glycol Fill Tank

A. Comply with requirements specified in Section 232513 “Water Treatment for HVAC Closed-Loop Hydronic Systems”.

2.7 PIPING AND FITTINGS

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."

C. Balancing Valves, Pressure-Reducing Valves, Pressure Relief Valves, and Safety Valves: Comply with requirements specified in Section 232116 “Hydronic Piping Specialties”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for installation and other conditions affecting performance of the Work.

B. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

C. Examine roughing-in for solar-collector piping to verify actual locations of piping connections before solar-panel installation.

D. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

E. Examine walls and roofs for suitable conditions where solar collector will be installed.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION

A. Install solar equipment where indicated on plans in accordance with manufacturer's installation recommendations. Coordinate equipment location with piping, ductwork, conduit and equipment of other trades to allow for sufficient clearances. Locate equipment and arrange piping to provide access space for servicing all components.

3.3 SOLAR COLLECTOR PANEL INSTALLATION

A. Comply with manufacturer's written instructions for collector mounting and installation.

B. Install the collector according to ASHRAE's "Active Solar Heating Systems Installation Manual."

C. Solar collector panels shall be assembled as shown on schematics in banks of equal number of collectors.

D. Solar collector panels shall be arranged with sufficient spacing such that no shading from other collector panels is evident between 1000 and 1400 hours of solar time on December 21.

E. Install low-voltage wiring from the sensor to the energy-management panel.

F. Mount the collector frame support feet to the structural support steel using stainless-steel bolts. Attach each pair of legs using two bolts for each.

G. Place high-temperature-resistant covers over the header to prevent contaminants from entering the headers.

H. Coat the controller's sensor with a layer of thermal paste and insert into the collector sensor port to full depth. Apply a silicone sealant around the entire perimeter of the sensor where it enters the collector. Completely cover the opening with insulation to prevent water ingress. Only use high-temperature-rated minimum 395 deg F sensors and cabling.

I. Install collectors with not less than minimum space for access and service as recommended by solar-collector manufacturer.

J. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties". Drawings indicate general arrangement of piping, fittings, and specialties.

K. Install calibrated balancing valves at the inlet of each collector bank in accordance with manufacturer's recommendations.

L. Where installing piping adjacent to solar collectors, allow space for service and maintenance.

M. Install flexible connections on piping between collectors installed in series.

N. Install ball valve and union at inlet and outlet of solar collectors. Comply with requirements in Section 230523 "General-Duty Valves for HVAC Piping" and Section 232116 "Hydronic Piping Specialties" for materials and installation requirements for ball valves and unions.

O. After connecting the inlet and outlet of the collectors to the system, purge the system of all air.

P. Locate manually operated air vents at system high points, and pitch array piping so that piping drains by gravity.

Q. Solar equipment installers shall be NABCEP certified and if he or she can show experience of being the lead worker on five (5) solar thermal projects where at least two (2) of them must be commercial projects

1. The qualified and certified installer has to be the supervisor at the job site during installation
2. Solar system shall be installed per IMC 1401 Solar Systems and Wisconsin SPS 371

3.4 SOLAR ARRAY SUPPORT STRUCTURE

A. Support structure shall secure solar collector panel array at the specified tilt angle with respect to horizontal and shall be oriented with respect to true south as required by the solar collector panels.

B. Support structure shall allow access to all equipment for maintenance, repair, and replacement.

3.5 SOLAR HOT WATER STORAGE TANK

A. Install solar hot water storage tanks where indicated on plans and in accordance with manufacturer's installation recommendations. Coordinate equipment location with piping, conduit, and equipment of other trades to allow for sufficient clearances. Locate equipment and arrange piping to provide access space for servicing all components.

B. Ensure enough clearance is provided to allow for in-tank heat exchanger removal.

C. Set solar hot water storage tank on housekeeping pad. Refer to Division 03 specifications for housekeeping pad requirements. Adjust and level solar hot water storage tank.

D. Provide piping, unions, valves, thermometers, relief valves, and all necessary fittings and accessories necessary for installation.

3.6 IN-TANK WATER-WATER HEAT EXCHANGER

A. Install in-tank water-water heat exchangers where indicated on details and schematics. Install in-tank water-water heat exchangers in accordance with manufacturer's installation recommendations. Coordinate equipment location with piping, conduit, and equipment of other trades to allow for sufficient clearances. Locate equipment and arrange piping to provide access space for servicing all components.

B. Ensure enough clearance is provided to allow for in-tank heat exchanger removal.

C. Connect in-tank water-water heat exchangers to piping using unions or flanges and isolation valves.

3.7 SOLAR HOT WATER PUMPS

A. Comply with ANSI/HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

D. Engage a factory-authorized service representative to perform alignment service.

E. Comply with requirements in Section 230523 "General-Duty Valves for HVAC Piping" and Section 232116 "Hydronic Piping Specialties" to connect pumps to piping. Drawing details and schematics indicate general arrangement of piping, fittings, and specialties.

F. Where installing piping adjacent to pump, allow space for service and maintenance.

G. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

H. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

I. Install check, shutoff, and throttling valves on discharge side of pumps.

J. Install Y-type strainer and shutoff valve on suction side of pumps.

K. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

L. Ground equipment according to Division 26.

M. Connect wiring according to Division 26.

3.8 SOLAR HOT WATER EXPANSION TANK

A. Install solar hot water expansion tank where indicated on details and schematics. Install in-tank water-water heat exchangers in accordance with manufacturer's installation recommendations. Coordinate equipment location with piping, conduit, and equipment of other trades to allow for sufficient clearances. Locate equipment and arrange piping to provide access space for servicing all components.

B. Connect solar hot water expansion tank to piping using unions or flanges and isolation valves.

3.9 SOLAR HOT WATER GLYCOL FILL TANK

A. Install solar hot water glycol fill tank where indicated on details and schematics. Install in-tank water-water heat exchangers in accordance with manufacturer's installation recommendations. Coordinate equipment location with piping, conduit, and equipment of other trades to allow for sufficient clearances. Locate equipment and arrange piping to provide access space for servicing all components.

B. Connect solar hot water glycol fill tank to piping using unions or flanges and isolation valves.

3.10 STARTUP SERVICE

A. SOLAR COLLECTOR PANELS

1. Engage a factory-authorized service representative to perform startup service.

    a. Complete installation and startup checks according to manufacturer's written instructions.
    b. Verify tilt angle, mounting, fluid concentrations, and collector array arrangement.

B. SOLAR HOT WATER STORAGE TANK

C. IN-TANK WATER-WATER HEAT EXCHANGER

D. SOLAR HOT WATER PUMPS

1. Engage a factory-authorized service representative to perform startup service.

    a. Complete installation and startup checks according to manufacturer's written instructions.
    b. Check piping connections for tightness.
    c. Clean strainers on suction piping.
    d. Perform the following startup checks for each pump before starting:
    e. Verify bearing lubrication.

f. 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.
g. Verify that pump is rotating in the correct direction.
h. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
i. Start motor.
j. Open discharge valve slowly.
k. Ensure pumps operate at specified system fluid temperatures without vapor binding or cavitation and are non-overloading in both parallel and individual operation.

3.11 ADJUSTING

A. Adjust tilt angle per design requirement and adjust the collector balance valve to provide the design flow.

END OF SECTION 23 56 13

SECTION 23 62 00

PACKAGE COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each compressor and condenser unit. Include:

1. Rated capacities, operating characteristics, and furnished specialties and accessories.
2. Equipment roof curbs, equipment supports, and roof penetrations.
3. Modulating hot gas reheat capacities, refrigeration circuit and with matching indoor unit with hot gas reheat coil.
4. Equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
5. Certified unit or fan-sound power ratings.
6. Motor ratings, electrical characteristics, and motor and fan accessories.
7. Wiring Diagrams: Power, signal, and control wiring, clearly indicating factory installed and field installed wiring.
8. All other included accessories.
9. Warranty data.
10. Roof curbs, rails and equipment supports per 230529 “Hangers and Supports for HVAC Piping and Equipment”.

B. LEED Submittals:

1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1.
2. Product Data for Credit EA 4: Documentation indicating that compressor and condenser units and refrigerants comply.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label water-cooled compressor and condenser units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-In-Place Concrete" and Section 033053 "Miscellaneous Cast-In-Place Concrete."

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 "Roof Accessories."

C. Coordinate location of piping and electrical rough-ins.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Compressor failure.
b. Condenser coil leak.

2. Warranty Period: Five years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Supply one (1) complete charge of lubricating oil in addition to that placed in system.

PART 2 - PRODUCTS

2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, NOMINAL 5 TO 20 TONS

A. Basis-of-Design Product: The design is based on the following:

1. Aaon

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Daikin/McQuay International.
2. Carrier Corporation.
3. Trane; a business of American Standard Companies.
4. YORK; a Johnson Controls company.

C. Description: Factory assembled and tested, air cooled; consisting of casing, digital compressors, condenser coils, ECM condenser fans and motors, and unit controls.

D. Digital Scroll Compressor: Hermetic scroll compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

1. Capacity Control: Variable capacity digital scroll as scheduled.
2. Capable of modulation from 10-100% of its capacity.

E. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.

1. Designed for R-410A refrigerant.
2. Minimum 10 °F refrigerant sub-cooling.

F. Refrigeration circuit shall be provided with modulating hot gas reheat valve with matching indoor unit with hot gas reheat coil.

G. Condenser Fans: Propeller-type, axial flow, vertical or horizontal discharge; direct drive fan. Include the following:

1. Permanently lubricated, ball-bearing totally enclosed motors with inherent overload protection.
2. Separate motor for each fan.
3. Dynamically and statically balanced fan assemblies.
4. Electrically commutated motor (ECM).
5. Condenser head pressure controller for modulation down to 35 °F.

H. Operating and safety controls include the following:

1. Manual-reset, high-pressure cutout switches.
2. Automatic-reset, low-pressure cutout switches.
3. Low-oil-pressure cutout switch.
4. Compressor-winding thermostat cutout switch.
5. Three-leg, compressor-overload protection.
6. Control transformer.
7. Liquid receiver and liquid line filter driers shall be factory provided.
8. Magnetic contactors for compressor and condenser fan motors.
9. Timer to prevent excessive compressor cycling.

I. Accessories:

1. Gage Panel: Package with refrigerant circuit suction and discharge gages for each circuit.
2. Oil pressure gauge.
3. Suction pressure transducer on the refrigeration circuit.
4. Modulating hot gas reheat shall be provided with factory mounted electronic controller for dehumidification control. Reset via 0-10V DC input signal.
5. Factory installed and factory wired, non-fused disconnect switch. Control circuit transformer and wiring with 24 VAC control voltage from line voltage to the unit.

J. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to digital compressors, controls, ECM condenser fans, motors, and drives. Additional features include the following:

1. Steel, galvanized, or zinc coated for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
3. Gasketed control panel door.
4. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
5. Condenser coil grille.
6. Provide hail guards on the condensing coils.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate compressor and condenser units according to ARI 306/110.

B. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings," Section 6, "Heating, Ventilating, and Air-Conditioning."

C. Testing Requirements: Factory test sound-power-level ratings according to ARI 370.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install units level and plumb, firmly anchored in locations indicated.

B. Install roof-mounting units on equipment supports specified in Division 07 "Roof Accessories."

C. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Comply with requirements for piping in other Section 232300 "Refrigerant Piping" for Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Compressor and condenser units will be considered defective, if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Inspect for physical damage to unit casing.
b. Verify that access doors move freely and are weathertight.
c. Clean units and inspect for construction debris.
d. Verify that all bolts and screws are tight.
e. Adjust vibration isolation and flexible connections.
f. Verify that controls are connected and operational.

B. Lubricate bearings on fan motors.

C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

E. Measure and record airflow and air temperature rise over coils.

F. Verify proper operation of condenser capacity control device.

G. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

H. After startup and performance test, lubricate bearings.

I. Provide cooling season start-up and winter season shut-down for first year of operation.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain compressor and condenser units.

END OF SECTION 23 62 00

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SECTION 23 72 00

AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Packaged energy recovery units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include manufacturer's descriptive literature including temperature and pressure rating, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Heat recovery equipment efficiencies for Total Enthalpy at design conditions;
3. ECM Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Fan construction and accessories.
    c. Fan-sound power ratings.

4. Material gages, panel construction, and finishes.
5. Motor ratings, electrical characteristics, and motor and fan accessories.
6. Wiring Diagrams: Power, signal, and control wiring, clearly indicating factory installed and field installed wiring.
7. Filters with performance characteristics
8. Dampers, including housings, linkages, and operators per Section 230900 "Instrumentation and Control for HVAC".
9. All other included accessories.
10. For unit: Trap detail in accordance with the unit details, verifying the trap will clear the floor with a 4" unit support such as a concrete pad or curb. The unit base shall be high enough to ensure the trap clears the mezzanine floor.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment compliance.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

B. Submit manufacturer's installation instructions.

C. Submit dimensioned drawings showing accurately scaled equipment and components, and required clearance and space relationships.

D. Include fan curves showing CFM, external and total static pressure, and RPM for operating range of 10% above and below design conditions.

E. Submit manufacturer's descriptive literature including heat recovery equipment efficiencies at design conditions; temperature and pressure ratings; materials of construction; weights; and control sequencing and interface.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) of each type of filter specified.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of units and are based on the specific system indicated.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

E. ARI Compliance:

1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."

F. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
3. The results shall be presented in accordance with ARI 1060 standards.

G. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

H. UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

1.7 COORDINATION

A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Deliver, store, protect and handle units to site under the supervision of the Owner and per Manufacturer's recommendations. Refer to Manufacturer's Installation, Operation and Maintenance Instructions Manual for proper installation procedures. Manufacturer is not responsible for any damage done to the units caused by poor rigging or installation operation.

D. Coordinate sizes and locations of equipment supports with actual equipment provided.

E. Coordinate location of electrical rough-ins.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy Recovery Units: Two years.

PART 2 - PRODUCTS

2.1 PACKAGED ENERGY RECOVERY UNITS

A. Basis-of-Design Product: The design is based on the following:

1. RenewAire LLC.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Addison Corporation
2. Greenheck Fan Corporation.
3. Lossnay; Mitsubishi.
4. Nortek/CES Group: Ventrol or Venmar.
5. VTS Group.

C. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and calked weathertight, hinged access doors removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1-inch- thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.

1. Casing shall be double-wall.
2. Casing Insulation: Minimum 1 inch thick 1.5 lb density thermal insulation.

E. Heat Recovery Device: Fixed-plate heat exchanger, static-core technology capable of transferring both sensible and latent energy between airstreams.

F. Direct-Driven Fans: Backward curved plenum; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

G. ECM motor ECM electronically commutated motor system is a single or three-phase motor for continuously variable speed control for exhaust fans for motors less than 2 HP.

1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

H. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: 2 inches.
5. Initial Resistance: 0.25 inches wg..
6. Recommended Final Resistance: 0.5 inches wg.
7. Minimum Arrestance: 80, according to ASHRAE 52.1.
8. Minimum Merv: 7, according to ASHRAE 52.2.
9. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

I. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.

1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
3. Include fused disconnect switches.
4. Variable-speed controller to vary fan capacity from 100 to approximately 50 percent.

J. Accessories:

1. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed parallel-blade arrangement with cadmium-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.
2. Isolation Dampers: Opposed-blade, galvanized-steel dampers with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
3. Duct flanges.
4. Rubber-in-shear isolators for ceiling-mounted units.
5. Hinged access doors with quarter-turn latches.
6. Drain pans for condensate removal complying with ASHRAE 62.1.
7. Automatic, in-place, spray-wash system.

2.2 CONTROL

A. Control are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

2.3 CAPACITIES AND CHARACTERISTICS:

A. Refer to Schedule on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

B. Install units with clearances for service and maintenance.

C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

D. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. Mount units at proper height above floor/mezzanine so that proper trap depth is provided in condensate drain.

3.3 CONNECTIONS

A. Connect condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

B. Install electrical devices furnished with units but not factory mounted.

C. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment piping, ducts, or other parts of the work, the Contractor shall rectify such conditions to the satisfaction of the Owner without cost to the Contract. If the equipment is judged to produce objectionable noise or vibration, demonstrate without cost to the Contract that the equipment performs within the designated vibration limits specified.

D. Install thermometer at each side of both supply and exhaust air streams.

E. Install pressure gauge equal to Dwyer Series 2000 Magnehelic across unit in supply air stream.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. 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. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-to-air energy recovery equipment will be considered defective, if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-to-air energy recovery system testing, adjusting, and balancing.

3.6 CLEANING

A. Clean units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and fixed plate core entering air face.

B. After completing system installation and testing, adjusting, and balancing units and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 00

SECTION 23 73 00

CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes custom make-up air and air-handling units. The following units:

1. MAU-B1, B2, C1, C2, D1 and E1.
2. AHU-A1.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of custom make-up and air-handling units indicated. Include the following:

1. Unit dimensions, weight and splits.
2. Scaled dimensions drawing(s) of the unit showing clearly labeled component locations, piping, duct and electrical connection locations and sizes.
3. Casing construction details including floor structure, internal structure, panel construction, wall-floor joint construction, wall-roof joint construction, insulation material and thickness, drain locations, method of pipe penetration and sealing, and any other field assembly details.
4. Fans:
    a. For variable volume applications, indicate all operating points on fan curves including data to indicate effect of capacity control devices on flow, pressure, and horsepower.
    b. Certified fan-performance curves with system operating conditions indicated.
    c. Fan construction and accessories.
    d. Certified fan-sound power ratings.
5. Certified coil-performance ratings with system operating conditions indicated.
6. Energy recovery performance rating with system operating conditions indicated.
7. Motor ratings, electrical characteristics, and motor and fan accessories.
8. Wiring Diagrams: Power, signal, and control wiring, clearly indicating factory installed and field installed wiring.
9. Material gages and finishes.
10. Split System Condensing Units per Section 236200 “Packaged Compressor and Condenser Units”.
11. Dampers, including housings, linkages, and operators per Section 230900 “Instrumentation and Control for HVAC”.
12. Airflow measuring stations (AFMS) per Section 230900 “Instrumentation and Control for HVAC”.
13. Filters with performance characteristics.
14. Face & bypass dampers with center bypass damper, including housings, linkages, and operators for energy recovery devices.
15. All other included accessories.
16. For AHU-A1 unit: Cooling coil trap detail in accordance with the unit details, verifying the trap will clear the floor with a 6” unit support such as a concrete pad or curb. The unit base shall be high enough to ensure the trap clears the mezzanine floor.

B. Field Quality-Control Test Reports: From manufacturer.

C. If Manufacturer cannot provide any of the items or options listed within this specification it must be noted as an exception on the bid.

D. LEED SUBMITTALS:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain air-handling units through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. NFPA Compliance: Air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

E. Comply with NFPA 70.

F. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

H. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

I. If units are supplied as separate components, each section shall have mating flanges for bolted assembly. All necessary closed-cell gasketing, caulking, nuts and bolts shall be provided. After final installation leakage from units shall not exceed ½ percent of total air volume handled at 1.5 times scheduled static pressure.

1.6 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations for packaged compressors and condensers units.

B. Coordinate size and location of structural-steel support members, if any, with actual equipment provided

C. Deliver, store, protect and handle units to site under the supervision of the Owner and per Manufacturer's recommendations. Refer to Manufacturer's Installation, Operation and Maintenance Instructions Manual for proper installation procedures. Manufacturer is not responsible for any damage done to the units caused by poor rigging or installation operation.

D. Furnish and install fabricated custom make-up air and air handling units where shown on the drawings and/or as scheduled. Provide units with design features as specified within this specification. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories

as specified. Any exceptions must be clearly defined. The Contractor shall be responsible for any additional expenses that may occur due to any exception made.

E. Coordinate location of refrigerant piping and electrical rough-ins.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set for each custom make-up and air-handling unit for supply/exhaust airstreams.
2. Gaskets: One set for each access door.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer Basis-of-Design Product: The design is based on the following:

1. Innovent

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Daikin/McQuay International.
2. Haakon Industries
3. Nortek/CES Group: Ventrol or Venmar
4. Addison Corporation

2.2 MANUFACTURED UNITS

A. Units shall be custom built factory assembled and consist of casing, fans, motor and drive assembly, coils, face and bypass dampers, center bypass damper, fixed-plate sensible heat exchangers, heat wheels, plenums, filters, condensate pans, drain pans, control devices, and accessories.

2.3 CUSTOM MAKE-UP AIR AND AIR HANDLING UNITS

A. Units may be shipped in sections, ready for field assembly. Assembly shall consist only of joining adjacent sections together. The unit manufacturer shall provide the necessary gasketing, caulking, nuts and bolts required for assembly. The manufacturer shall have assembled the units at factory prior to shipment to make sure the sections fit properly together and that the leakage from the units will not exceed ½ percent of the total volume handled at 1.5 times the scheduled static pressure of the supply air fan within unit.

B. “Under 55°F supply air temperature and design conditions on the exterior of the unit of 91°F dry bulb and 74°F wet bulb, condensation shall not form on the casing exterior. The unit manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, unit manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the unit manufacturer will cover all expenses associated with modifying or replacing units should external condensate form on them.”

C. Frame, Casing and Base:

1. The unit casings shall be double wall steel with a 16-gauge galvanized steel outer wall, a 22 gauge galvanized steel inner wall and insulation between inner and outer walls.

2. The entire unit shall be fabricated of welded tubular steel or framed construction channel framework complete with heavy gauge structural steel base. Inner surface shall cover all structural members. Cross members are to be designed to support all interior components. The casing panels shall not be required to maintain the structural integrity of the unit. After welding, all structural steel shall be cleaned and painted with one coat of zinc chromate primer and one coat of enamel paint (equal to Rustoleum systems 31-0000 enamel) before panel attachment.
3. Lifting lugs shall be provided on each corner of each section to allow for rigging.
4. A means shall be provided around each section for joining each section together with stainless steel nuts and bolts.
5. The primary floor shall be 1/8" hot rolled steel, fully sealed or welded at all joints to prevent leakage of water, with a stainless-steel drain pan(s) over the entire floor surface. Sub-floor to be 16-gauge galvanized steel. The floor surface shall be coated with one coat of primer and one coat of asphalt base finish paint prior to installation of pan.
6. Fully Sealed or Welded Floor:

    a. A full perimeter base rail shall be installed at each unit. The base rail shall be constructed from a minimum of 16-gauge G90 galvanized steel and shall be at least 8” high.
    b. A 12 gauge galvanized steel smooth plate floor shall be installed on the base. Floor shall be flat reinforced from below, with all seams continuously welded. Drive screw attachment and caulking are not acceptable.

7. A drain shall be installed at the low point in the floor of each section. Connect a stainless steel pipe from each drain to the outside of the unit.
8. Cooling coil drain pans shall be continuously welded 304 stainless steel. Coil section must have intermediate drain pans and shall be interconnected with NPS 1-1/4 inch drain lines. Drain pans shall be IAQ sloped and fully drainable.
9. Stiffeners of angle steel shall be supplied as required to maintain casing deflection criteria of 1/200 at 1.5 times the working pressure. If panels cannot meet this deflection, add additional internal reinforcing.
10. Provide removable steel welded bar grating platforms over ducted openings in the bottom of the unit to prevent a fall hazard should someone enter the unit for servicing, cleaning, or inspection.
11. All internal partitions, blocking, fasteners, and miscellaneous materials shall be steel.

D. Insulation:

1. Wall, ceiling and floor of each section shall be insulated with a minimum of 2-inch-thick polyisocyanurate or urethane, or polyurethane insulation.
2. All insulation edges shall be protected with metal lagging. Insulation systems using stickpins or adhesives are not acceptable. Casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there is no path of continuous unbroken metal to metal conduction from inner to outer surfaces.

E. Access Doors:

1. Access doors shall be insulated double wall doors of same materials and thicknesses as unit walls, flush mounted with sides of unit. Removable panels are not acceptable access doors.
2. Access doors shall be a minimum of 20 inches wide and 60 inches high, and arranged for normal equipment inspection and maintenance. Access doors shall be provided in fan, coil and filter sections as required. Door corners shall be continuously, welded for rigidity. Fan compartments must have a door of minimum width to remove the motor.

    a. For units 60" high or less, 20" wide by 36" high minimum size access doors are required.

3. Access door frame shall consist of structural tubing fitted with vinyl bulb type seal mechanically secured to the frame. Access door hinges shall be heavy duty steel piano or strap type hinges fastened to the access door and frame, and cam-action handles which shall be operable from either side of door.

    a. Note: Piano type hinges shall only be permitted on the outside of the unit

b. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable. Hinges shall allow doors to open at 180° with no shear effect on the hinge side of the perimeter gasket. The door frame shall be extruded aluminum with a built-in thermal break barrier and full perimeter gasket. The door gasketing shall employ a double seal comprising of an adhesive neoprene compressible foam gasket on the outer door panel and an "automotive style" neoprene bulb gasket fixed onto the inner door frame for out-swing doors, "rippled" foam for in-swing doors.

c. Door handles shall be operable from both inside and outside of the unit. On all access doors where moving parts could cause injury, an ETL, UL 1995 and OSHA approved tool operated safety latch shall be provided. Manufacturer shall provide thermal break door design.

4. A hermetically sealed, thermally broken, double-glazed laminated glass window shall be provided in each door.
5. All access doors must swing against the air pressure (i.e. positive pressure plenum doors must swing in).

F. Access Panels:

1. Removable panels shall be provided in each coil section to allow for removal of fan and coil(s). Panels shall be insulated double wall type of same materials as unit walls.

G. Exterior Finish:

1. Exterior casing finish to be unit manufacturer's standard color enamel over galvannealed steel. Each section to be labeled for identification, with arrows showing direction of air flow. Corrosion resistant exterior paint finish shall withstand 1,000 hours of salt spray as per ASTM B-117.

H. Fan:

1. Fan Array Manufacturers: Twin City MPQN, Comefri, PennBarry ESA, Greenheck HPA, New York Blower FA, Huntair, CES Group or approved equal.
2. Direct Drive plug fan(s) having non-overloading horsepower characteristics, single-thickness airfoil fully welded blades with constantly rising pressure characteristics, and heavy gauge housing with steel supports.
3. Plug Fan (PF) SWSI Minimum Class II Fans: single width single inlet as indicated on the Drawings.
4. Fan to be statically and dynamically balanced at factory and given final testing with motor and drive in place.
5. Fan wheel, housing, frame, support base and isolators are to be epoxy finished. Fan shafts shall be solid, turned, ground and polished steel rated at maximum RPM below critical speed. Polymer wheel technology is acceptable in lieu of painted wheels.
6. Fans shall be both dynamically and statically balanced. Dynamic fan wheel balancing shall be conducted from 16 Hz to 105 Hz to identify and eliminate critical speeds to ensure stable operation through the entire operating range. Each individual fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance.
7. Plenum fan assembly must have an enclosed safety screen as per OSHA Standards.
8. Fans shall have OSHA approved inlet screens.
9. Fan-Section Source Quality Control:

   a. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

   b. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

10. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at the scheduled static pressure.
11. Unit's static pressure shall take into consideration actual static pressure loss of components furnished within unit and 1 inch wg. for dirty filter pressure drop.

12. Fan array with vertical blade backdraft dampers by CES Group which meets the system performance is acceptable.
13. Twin city's plenum fan with Aero Acoustic Diffuser™ which meets the system performance is acceptable with the discharge sound power reductions by up to 3 dBA while increasing aerodynamic static efficiency by up to 4%.

I. Motor and Drive:

1. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor to be furnished by unit manufacturer.
3. Motors to be totally-enclosed fan-cooled (TEFC), 460V/ 60 cycles/, 3 phase, with Class F insulation.
4. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.15.
5. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
6. Motors shall meet most current version of USA EPACT.
7. Each fan array shall also include motor removal rail located on the discharge side of the fan array. The rail shall span the full internal width of the unit.
8. All motors specified for used with variable speed drives (VFD's) shall be designed for inverter duty service.
9. Fan motors shall have permanently sealed non-greasable bearings.
10. Provide motor ground rings as specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
11. If unit(s) submitted have larger motor power requirements than scheduled in the drawings, the contractor shall be responsible for any additional electrical system upgrade costs.

J. Variable Frequency Drives:

1. Variable Frequency Drives are specified in Section 230514 "Variable Frequency Drives" and Section 230900 "Instrumentation and Control for HVAC". Variable Frequency Drives are to be furnished by Temperature Control Contractor and installed by Electrical Contractor.

K. Fan Vibration Isolation:

1. Each fan shall be mounted on a built-in isolation base, forming an integral structure for the fan, motor, and drive assembly. Base shall be fabricated from welded structural steel and be mounted on 1" deflection spring isolators, employing height saving clips. Unit shall be shipped with restraints to prevent movement of base during shipment. Spring isolators are not needed for direct drive fan arrays balanced in 3 planes.
2. Provide thrust resistors at discharge connection (across the flex connection) of each fan to prevent stretching of flex connection and transmission of fan vibration to the structure.

L. Coil Section:

1. Coils shall be on mounted galvanized steel angle racks manufactured to allow coils to slide out individually. Coils shall not act as structural component of unit. Provide stainless steel racks for AHU-A1 unit coils.
2. Fabricated according to ARI standard 410.
3. Copper tube with aluminum fin and header construction.
4. Entire coil frame, headers and U-bends shall be enclosed within unit casing. Extend coil piping connections, air vent and drain connections to exterior of casing/
5. Blank off space between coil frames and unit casing.
6. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.
7. Refrigerant Coils: Factory tested to 450 psig according to ARI 410 and ASHRAE 33.
8. Refer to Section 238216.11 "Hydronic Air Coils" and Section 238216.13 "Refrigerant Air Coils".
9. Provide hot gas reheat coil for air-handling unit AHU-A1.

M. Air Filtration Section:

1. Refer Specification Section 234100 "Particulate Air Filtration".

2. Comply with NFPA 90A.
3. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
4. Provide 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.
5. Filters shall be removable without the use of tools.
6. All filter framing and support materials shall be stainless steel.
7. Pre-filter:

    a. Filter: Type as scheduled on drawings.
    b. Housing: Provided and factory installed by AHU manufacturer.
    c. Pre-filter holding frames shall be rear loading four-sided type fabricated from stainless steel to prevent plugged filters from being drawn out of the filter framing by negative fan pressure to protect downstream coils, fans, and other downstream unit components.

N. Face and Bypass Dampers:

1. Provide face and bypass dampers for fixed-plate sensible heat exchangers and center bypass damper. Center bypass damper section shall be centered and in the middle between two sections of the fixed-plate sensible heat exchangers.
2. Integral dampers within the unit shall be of the tight-seal, airfoil blade type, 12-gauge extruded aluminum. Frames shall be 12-gauge extruded aluminum, rigid beam construction. Shafts shall be extruded aluminum. Linkage shall be provided between blades in the mullions to assure equal motion of all opposing blades. Blades shall be sealed with an extruded neoprene material at point where blades mate and with stainless steel jamb seal. Damper actuators shall be Belimo modulating proportional 24 VAC and control signal 0-10 VDC or 4-20 mA.

O. Fan Inlet Air Flow Stations

1. For fans that are specified or scheduled to have fan inlet air flow station, provide a piezometer ring air flow station mounted on the fan inlet bell housing. Pressure tubes from the piezometer ring shall be extended to a termination plate labeled with the high and low pressure connections. Provide an initial flow rate coefficient that will be adjusted by the balancing contractor for measured flow reading.
2. Piezometer ring air flow station shall measure static pressure drop through the fan inlet cone to provide an overall air flow measurement to within +/- 5% accuracy.
3. Differential pressure transducers for measuring the velocity pressure for air flow measurement shall be supplied under Section 230900 and be mounted in the temperature control panel.

P. Split Condensing Unit (AHU-A1):

1. Refer to Section 236200 “Packaged Compressor and Condenser Units”.

Q. Electrical Components:

1. Provide a marine LED type light fixture in each unit section, and a single light switch with integral pilot light on outside of unit.

    a. All lights and receptacles shall be wired from the factory to a separate junction box located on the exterior of the unit.
    b. Light circuit shall have its own disconnect switch separate from main unit disconnect.
    c. Lighting circuit shall not be disabled when main unit disconnect is operated.
    d. Provide GFCI convenience receptacle in 115V lighting circuit.

2. Provide a junction box and "seal tight" connections to allow power to be connected from one section to the next while joining the unit sections together in the field.
3. Wire and conduit shall be complete across shipping splits. The contractor shall re-make connections in the field. All unit splits shall comply with NEC 300.22 and shall be suitable for wet locations.

4. AHU manufacturer shall provide and install required transformer for 115-volt power.

R. Filter Gauges: Provide Dwyer 2000 (photohelic) magnehelic gauges accurate to ±2% of full range for each filter bank.

1. Differential pressure transducers for measuring the velocity pressure for air flow measurement shall be supplied under Section 230914 and be mounted in the temperature control panel

S. Sealants: In general, the use of caulking and sealants within the unit shall be minimized.

T. Fixed-Plate Sensible Heat Exchangers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. American Energy Exchange, Inc.
b. Des Champs Technologies.
c. Eclipse, Inc.; Exothermics Business Group.
d. Nutech Brands Inc.
e. UAS, Inc.; a CLARCOR company.
f. Heatex
g. Inergy
h. Allied Air Products, Co. (Temp-X-Changer)
i. Nortek Venmar
j. ACS-Hoval
k. Z Duct

2. Casing: Enameled steel, with galvanized-steel liner.

a. The heat exchanger and casing must be able to withstand 10" water column of pressure differential between air streams.
b. Access to all four sides of the exchanger for cleaning and inspection shall be provided.

3. Plates: Evenly spaced and sealed and arranged for crossflow arrangement airflow pattern.

a. Plate Material: Embossed aluminum.
b. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

4. Bypass: Plenum within casing, with gasketed face-and-bypass dampers and center damper that have operating rods extended outside casing. The bypass is sized for 50% of total airflow in the CNG mode.

U. Heat Wheels (AHU-A1):

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. American Energy Exchange, Inc.

2. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.
3. Casing:

a. Steel, with manufacturer's standard paint coating.
b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
c. Casing seals on periphery of rotor, on duct divider, and on purge section.

d. Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal motors on tapered roller bearing.

4. Wheel shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless steel or aluminum and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning.
5. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
6. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, and self-adjusting multilink belt around outside of rotor.
7. Controls:

a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
b. Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.
c. Pilot-Light Indicator: Display rotor rotation and speed.
d. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

2.4 CONTROL DAMPERS

A. Control dampers are specified in Section 230900 “Instrumentation and Control for HVAC”. Refer to Section 230900 for damper to be furnished and installed by Temperature Control Contractor.

2.5 AIRFLOW MEASURING STATION

A. The outside air damper and airflow measuring station (AFMS) are specified in Section 230900 “Instrumentation and Control for HVAC”. Refer to Section 230900 for outside air damper and air flow measuring station to be furnished by Temperature Control Contractor and installed by Mechanical Contractor.

2.6 FAN INLET AIR FLOW STATIONS

A. For fans that are specified or scheduled to have fan inlet air flow station, provide a piezometer ring air flow station mounted on the fan inlet bell housing. Pressure tubes from the piezometer ring shall be extended to a termination plate labeled with the high and low pressure connections. Provide an initial flow rate coefficient that will be adjusted by the balancing contractor for measured flow reading.

B. Piezometer ring air flow station shall measure static pressure drop through the fan inlet cone to provide an overall air flow measurement to within +/- 5% accuracy.

C. Differential pressure transducers for measuring the velocity pressure for air flow measurement shall be supplied under Section 230900 and be mounted in the temperature control panel.

2.7 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

D. Refrigerant Coils: Factory tested to 450 psig according to ARI 410 and ASHRAE 33.

E. LEAKAGE RATE

1. Leakage rate shall not exceed 1% of the total system air quantity when subjected to +/- 5” static pressure.

2.8 ELECTRICAL AND LIGHTS

A. Provide a marine grade LED light and GFI receptacle in all fan sections and marine LED grade light in all access sections on units as well as a switch located on the exterior of the fan section to control the lights.

B. All lights and receptacles shall be wired from the factory to a separate junction box located on the exterior of the air handling unit. The lights and receptacles must remain on if the air handling unit fans disconnects are switched off.

C. CAPACITIES AND CHARACTERISTICS:

1. Refer to Schedule on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine casing insulation materials and filter media before unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic, refrigeration 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.

3.2 INSTALLATION

A. Install all air handling units and accessories as indicated on drawings and/or as scheduled and according to manufacturer's installation instructions.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

C. Arrange installation of units to provide access space around units for service and maintenance.

D. Install units on flat surface level within 1/8" and of sufficient strength to support the units.

E. 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.

F. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

G. Comb out damaged fins where bent or crushed before covering elements with enclosures.

H. Mount units at proper height above floor so that proper trap depth is provided in condensate drain.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Connect condensate and other drain pans using NPS 1-1/4 inch if not detailed on the drawings. Pipe drains from drain pans to nearest floor drain or hub drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. Mount units at proper height above floor/mezzanine so that proper trap depth is provided in condensate drain.

E. Hot Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping."

G. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories." Drawings indicate general arrangement of ducts and duct accessories.

1. Ensure that metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.
2. Where inlet and outlet ductwork at any fan is changed from that shown on the drawings, provide any motor, drive, and/or wiring changes required due to increased static pressure or baffling necessary to prevent uneven airflow or improve mixing. In all cases obtain Approval before proceeding with changes to ductwork.

H. Electrical: Comply with applicable requirements in Division 26.

I. Ground equipment according to Division 26.

J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

K. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. The Contractor shall be responsible for any motor, drive, and/or wiring changes required as result of duct configuration changes at fan. In all cases obtain Approval before proceeding with changes to ductwork.

L. If a water coil has multiple inlet and outlet connections, provide a shutoff valve, pressure port, flexible connector, and union at each inlet connection and provide a balance valve, pressure port, thermometer, flexible connector, and union at each outlet connection.

3.4 CASING PENETRATIONS

A. Install sealing collars to the interior and exterior of each penetration to prevent air leakage where coil piping, air vents, drain piping, and electrical conduits penetrate unit casing. Silicone sealants and duct sealants are not acceptable to seal pipe penetrations of the unit casing.

B. Duct sealant and/or gaskets as indicated in specification section 233113 may be utilized to seal duct connections to the unit casing. Silicone sealants are not acceptable.

3.5 LEAKAGE TEST

A. Field test all custom make-up air and air handling units.

B. Seal all openings and dampers at the unit to the pressure class listed below before performing the test. A minimal amount of ductwork may be connected to the unit in order to seal off large openings. The ductwork must meet or exceed the larger of the ductwork pressure class or the unit pressure requirement.

C. Test draw through units at -5” static pressure. The contractor and/or the unit manufacturer may brace the access doors in positive sections of the unit to meet the testing requirements.

D. If excessive air leakage is found locate leaks, repair in the area of the leak, seal, and retest. Leakage rate shall not exceed more that 1% of the total system air quantity when subjected to +/- 5” static pressure.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

   1. Leak Test: After installation, fill water coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. 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, starters, and disconnect switches.
   4. Perform cleaning and adjusting specified in this Section.
   5. Verify proper motor rotation direction, free fan wheel rotation and smooth bearing operations.
   6. Verify fan isolators have proper deflection.

7. Verify that outdoor and existing air dampers open and close.
8. Comb coil fins for parallel orientation.
9. Install clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for custom make-up and 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.

D. Refer to Section 230593 "Testing, Adjusting, and Balancing for HVAC" for custom make-up air and air-handling system's testing, adjusting, and balancing.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for make-up air and air-handling system testing, adjusting, and balancing.

3.9 CLEANING

A. Clean units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing units and air-distribution systems, clean filter housings and install new filters.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain custom make-up air and air-handling units.

END OF SECTION 23 73 00

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SECTION 23 73 13

MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes modular indoor central-station air-handling units.

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions, weight and splits.
2. Casing construction details including floor structure, internal structure, panel construction, wall-floor joint construction, wall-roof joint construction, insulation material and thickness, drain locations, method of pipe penetration and sealing, and any other field assembly details.
3. Fans:

    a. For variable volume applications, indicate all operating points on fan curves including data to indicate effect of capacity control devices on flow, pressure, and horsepower.
    b. Certified fan-performance curves with system operating conditions indicated.
    c. Fan construction and accessories.
    d. Certified fan-sound power ratings.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Motor ratings, electrical characteristics, and motor and fan accessories.
6. Wiring Diagrams: Power, signal, and control wiring, clearly indicating factory installed and field installed wiring.
7. Material gages and finishes.
8. Split System Condensing Units per Section 236200 “Packaged Compressor and Condenser Units”.
9. Dampers, including housings, linkages, and operators per Section 230900 “Instrumentation and Control for HVAC”.
10. Airflow measuring stations (AFMS) per Section 230900 “Instrumentation and Control for HVAC”.
11. Filters with performance characteristics.
12. All other included accessories.
13. For AHU-E1 unit: Cooling coil trap detail in accordance with the unit details, verifying the trap will clear the floor with a 6” unit support such as a concrete pad or curb. The unit base shall be high enough to ensure the trap clears the mezzanine floor.

B. Field Quality-Control Test Reports: From manufacturer.

C. If Manufacturer cannot provide any of the items or options listed within this specification it must be noted as an exception on the bid.

D. LEED SUBMITTALS:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain air-handling units through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NFPA 70.

E. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

F. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

H. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

I. If units are supplied as separate components, each section shall have mating flanges for bolted assembly. All necessary closed-cell gasketing, caulking, nuts and bolts shall be provided. After final installation leakage from units shall not exceed ½ percent of total air volume handled at 1.5 times scheduled static pressure.

1.5 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations for packaged compressors and condensers units.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

C. Deliver, store, protect and handle units to site under the supervision of the Owner and per Manufacturer's recommendations. Refer to Manufacturer's Installation, Operation and Maintenance Instructions Manual for proper installation procedures. Manufacturer is not responsible for any damage done to the units caused by poor rigging or installation operation.

D. Furnish and install fabricated modular indoor central-station air handling units where shown on the drawings and/or as scheduled. Provide units with design features as specified within this specification. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined. The Contractor shall be responsible for any additional expenses that may occur due to any exception made.

E. Coordinate location of refrigerant piping and electrical rough-ins.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set for each custom make-up and air-handling unit for supply/exhaust airstreams.
2. Gaskets: One set for each access door.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: The design is based on the following:

1. Daikin/McQuay International.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Addison Corporation
2. Greenheck Fan Corporation.
3. Nortek/CES Group: Ventrol, Venmar, Temtrol, and Governair.
4. JCI/YORK International Corporation.
5. Valent

2.2 MODULAR INDOOR UNITS

A. Units shall be modular indoor factory assembled and consist of casing, fans, motor and drive assembly, coils, plenums, filters, condensate pans, drain pans, control devices, and accessories.

B. Units may be shipped in sections, ready for field assembly. Assembly shall consist only of joining adjacent sections together. The unit manufacturer shall provide the necessary gasketing, caulking, nuts and bolts required for assembly. The manufacturer shall have assembled the units at factory prior to shipment to make sure the sections fit properly together and that the leakage from the units will not exceed ½ percent of the total volume handled at 1.5 times the scheduled static pressure of the supply air fan within unit.

C. Under 55°F supply air temperature and design conditions on the exterior of the unit of 91°F dry bulb and 74°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying or replacing units should external condensate form on them.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.
4. Factory Finish for Steel and Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat. Architect to select color from one standard manufacturer’s color charts. Each section to be labeled

for identification, with arrows showing direction of air flow. Corrosion resistant exterior paint finish shall withstand 1,000 hours of salt spray as per ASTM B-117

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type II.
2. Location and Application: Encased between outside and inside sheetmetal casing.

C. Wall/Roof Construction

1. Construct walls and roof from 2-inch-thick double wall panel assemblies. Panels shall be injected with polyisocyanurate or urethane, or polyurethane foam insulation and shall have a minimum thermal conductivity (R) of at least 12.5. The outer shell shall be constructed of solid G90 galvanized steel with baked enamel finish. The inner liner shall be constructed of solid G90 galvanized steel. Panels shall be gasketed with permanently applied bulb-type gaskets and able to be removed without affecting the integrity of casing structure.
2. Outside Casing: Galvanized steel, minimum 0.0336-inch-thick, 22 gauge.
3. Inside Casing: Galvanized steel, solid, minimum 0.0336-inch-thick, 22 gauge.
4. Perforated liner to be used for supply/return air plenums for sound attenuation.

D. Floor Construction

1. Construct floors from 2-inch-thick double wall panel assemblies. Panels shall be injected with polyisocyanurate or urethane, or polyurethane foam insulation and shall have a minimum thermal conductivity (R) of at least 12.5. The outer shell shall be constructed of solid G90 galvanized steel with baked enamel finish. The inner liner shall be constructed of solid G90 galvanized steel. Panels shall be gasketed with permanently applied bulb-type gaskets.
2. A full perimeter base rail shall be installed at each air handling unit. The base rail shall be constructed from a minimum of 16-gauge G90 galvanized steel and shall be at least 8” high. Panels shall be able to be removed without affecting the integrity of casing structure.
3. Floor Plate: Galvanized steel, minimum 0.0336-inch-thick, 22 gauge.

E. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:

    a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

    a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Size: At least 24 inches wide by full height of unit casing up to a maximum height of 72 inches.

4. Locations and Applications:

    a. Fan Section: Doors.

b. Access Section: Doors.
c. Coil Section: Inspection and access panel.
d. Upstream and downstream of every Damper Section: Doors.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.
g. Doors shall always open against pressure

5. Removable panels:

a. Removable panel shall be provided in each coil section to allow for removal of fan and coil(s). Panels shall be insulated double wall type of same materials as unit walls.

F. Condensate Drain Pans:

1. 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 to direct water toward drain connection.

a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
b. Depth: A minimum of 2 inches deep.

2. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
4. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

G. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan Plenum Manufacturers: Twin City MPQN, Comefri, PennBarry ESA, Greenheck HPA, New York Blower FA, Huntair or approved equal.

B. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

C. Direct Drive Fans. direct driven, arrangement 4 plenum fan constructed per AMCA requirements for the duty specified, (Class I, II or III).

D. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

1. Plug Fan (PF) SWSI Minimum Class II Fans: single width single inlet as indicated on the Drawings. Fan wheel has a minimum of 12 blades made from extruded aluminum as a hollow airfoil in shape, and welded to the center and wheel side plates. The fan Inlet cone is made from spun aluminum material. Fan wheel shall be keyed to the shaft.
2. Fans shall be both dynamically and statically balanced. Dynamic fan wheel balancing shall be conducted from 16 Hz to 105 Hz to identify and eliminate critical speeds to ensure stable operation through the entire

operating range. Each individual fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance.

3. Fans shall be rated in accordance with AMCA 210 for performance and AMCA 300 for sound.
4. Fan motors are premium efficiency and compatible for inverter duty per Section 230513 "Common Motor Requirements for HVAC Equipment."
5. Fan motors shall have permanently sealed non-greasable bearings.

E. ECM Fan Manufacturers: Ebm-papst Company K3G series or approved equal.

1. Provide ECM, motorized multi-blade backward-curved, single impeller fan(s). Fan assembly shall include fan, fan base, and a high efficiency permanent magnet ECM direct drive motor and shall be dynamically balanced by the fan manufacturer.
2. Motor control panel shall come with a low voltage terminal strip and shall include terminals for Fan ON/OFF, 0-10V control signal, and fan fault.
3. Motor control panel shall come equipped with a fused disconnect.
4. Fan section shall come equipped with a motor control panel mounted on the fan section. Both line voltage and low voltage wiring shall be done by the factory. Each fan shall have an isolation switch.
5. Motor shall be brushless DC type with a permanent magnet rotor.
6. Inverter shall be integral to the motor and come as an assembly from the fan manufacturer.

F. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at the scheduled static pressure.

G. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 2 inches.

H. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor to be furnished by unit manufacturer.
2. Motors to be totally-enclosed fan-cooled (TEFC), 460V/ 60 cycles/, 3 phase, with Class F insulation.
3. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
4. Motors shall meet most current version of USA EPACT.
5. 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 1.15.
6. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
7. Mount unit-mounted disconnect switches on exterior of unit for ECM motors.
8. Fan motors shall have permanently sealed non-greasable bearings.
9. Provide motor ground rings as specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Motor furnished with fan shall not operate into motor service factor in any case. Drive efficiency shall be considered in motor selection according to motor manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

J. If unit(s) submitted have larger motor power requirements than scheduled in the drawings, the contractor shall be responsible for any additional electrical system upgrade costs.

K. Variable Frequency Drives:

1. Variable Frequency Drives are specified in Section 230514 “Variable Frequency Drives” and Section 230900 “Instrumentation and Control for HVAC”. Variable Frequency Drives are to be furnished by Temperature Control Contractor and installed by Electrical Contractor.

2.5 SPLIT CONDENSING UNIT (AHU-E1)

A. Refer to Section 236200 “Packaged Compressor and Condenser Units”.

2.6 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 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. Coils shall not act as structural component of unit.

B. Cooling coils shall be sized and arranged to prevent moisture carryover. Cooling coils shall be sized for the maximum face velocity indicated on the drawings. If two or more coils are stacked in the unit, intermediate drain channels shall be installed between coils to drain condensate to the main drain pans without flooding the lower coils or passing condensate through the airstream of the lower coil. Provide stainless steel racks for AHU-E1 unit coils.

C. Air handling unit coils mounted in casing shall be accessible for removal from either side of unit casing without disturbing adjacent sections.

D. Entire coil frame, headers and U-bends shall be enclosed within air handling unit casing. Extend coil piping connections, air vent and drain connections to exterior of casing.

E. Support coils along entire length within casing and pitch coil for proper drainage.

F. Blank off space between coil frames and air handling unit casing.

G. Support coils along their entire length within the cabinet and pitch for proper drainage.
1. Coil selection shall account for a water side fouling factor of 0.0001 hr-ft2-°F/Btu for water systems, 0.0001 for glycol systems with non-ferrous tubes, and 0.0002 for glycol systems with ferrous tubes.

H. Refer to Section 238216.11 “Hydronic Air Coils” and Section 238216.13 “Refrigerant Air Coils”. Provide hot gas reheat coil for air-handling unit AHU-E1.

2.7 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on one service side of unit. Filters shall be removable from one side or lifted out from access plenum.
4. Filter box section may be furnished by air handling unit manufacturer in accordance with specification requirements of section 234100.
5. Filter Gauges: Provide Dwyer 2000 (photohelic) magnehelic gauges accurate to ±2% of full range for each filter bank.
6. Filters shall be removable without the use of tools.
7. All filter framing and support materials shall be stainless steel.
8. Provide static pressure tips that are arranged to prevent damage to the filter elements during replacement. Provide minimum 2” gap between final and prefilters for static pressure probes.

B. Refer to Section 234100 “Particulate Air Filtration”

2.8 CONTROL DAMPERS

A. Control dampers are specified in Section 230900 “Instrumentation and Control for HVAC”. Refer to Section 230900 for damper to be furnished and installed by Temperature Control Contractor.

2.9 AIRFLOW MEASURING STATION

A. The outside air damper and airflow measuring station (AFMS) are specified in Section 230900 “Instrumentation and Control for HVAC”. Refer to Section 230900 for outside air damper and air flow measuring station to be furnished by Temperature Control Contractor and installed by Mechanical Contractor.

2.10 FAN INLET AIR FLOW STATIONS

A. For fans that are specified or scheduled to have fan inlet air flow station, provide a piezometer ring air flow station mounted on the fan inlet bell housing. Pressure tubes from the piezometer ring shall be extended to a termination plate labeled with the high and low pressure connections. Provide an initial flow rate coefficient that will be adjusted by the balancing contractor for measured flow reading.

B. Piezometer ring air flow station shall measure static pressure drop through the fan inlet cone to provide an overall air flow measurement to within +/- 5% accuracy.

C. Differential pressure transducers for measuring the velocity pressure for air flow measurement shall be supplied under Section 230900 and be mounted in the temperature control panel.

2.11 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

D. Refrigerant Coils: Factory tested to 450 psig according to ARI 410 and ASHRAE 33.

2.12 LEAKAGE RATE

A. Leakage rate shall not exceed 1% of the total system air quantity when subjected to +/- 5” static pressure.

2.13 ELECTRICAL AND LIGHTS

A. Provide a marine grade LED light and GFI receptacle in all fan sections and marine LED grade light in all access sections on units as well as a switch located on the exterior of the fan section to control the lights.

B. All lights and receptacles shall be wired from the factory to a separate junction box located on the exterior of the air handling unit. The lights and receptacles must remain on if the air handling unit fan’s disconnects are switched off.

2.14 CAPACITIES AND CHARACTERISTICS:

A. Refer to Schedule on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic, refrigeration 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.

3.2 INSTALLATION

A. Install all air handling units and accessories as indicated on drawings and/or as scheduled and according to manufacturer's installation instructions.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

F. Install units on flat surface level within 1/8" and of sufficient strength to support the units.

G. Comb out damaged coil fins where bent or crushed before covering elements with enclosures.

H. Mount units at proper height above floor so that proper trap depth is provided in condensate drain.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate and other drain pans using NPS 1-1/4 inch if not detailed on the drawings. Pipe drains from drain pans to nearest floor drain or hub drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. Mount units at proper height above floor/mezzanine so that proper trap depth is provided in condensate drain.

E. Hot Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping."

G. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories." Drawings indicate general arrangement of ducts and duct accessories.

1. Ensure that metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.
2. Where inlet and outlet ductwork at any fan is changed from that shown on the drawings, provide any motor, drive, and/or wiring changes required due to increased static pressure or baffling necessary to prevent uneven airflow or improve mixing. In all cases obtain Approval before proceeding with changes to ductwork.

H. Electrical: Comply with applicable requirements in Division 26.

I. Ground equipment according to Division 26.

J. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. The Contractor shall be responsible for any motor, drive, and/or wiring changes required as result of duct configuration changes at fan.

K. If a water coil has multiple inlet and outlet connections, provide a shutoff valve, pressure port, flexible connector, and union at each inlet connection and provide a balance valve, pressure port, thermometer, flexible connector, and union at each outlet connection

3.4 CASING PENETRATIONS

A. Install sealing collars to the interior and exterior of each penetration to prevent air leakage where coil piping, air vents, drain piping, and electrical conduits penetrate unit casing. Silicone sealants and duct sealants are not acceptable to seal pipe penetrations of the unit casing.

B. Duct sealant and/or gaskets as indicated in specification section 233113 may be utilized to seal duct connections to the unit casing. Silicone sealants are not acceptable.

3.5 LEAKAGE TEST

A. Field test all modular air handling units.

B. Seal all openings and dampers at the air handling unit to the pressure class listed below before performing the test. A minimal amount of ductwork may be connected to the air handling unit in order to seal off large openings. The

ductwork must meet or exceed the larger of the ductwork pressure class or the air handling unit pressure requirement.

C. Test draw through air handling units at -5" static pressure. 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. If excessive air leakage is found locate leaks, repair in the area of the leak, seal, and retest. Leakage rate shall not exceed more that 1% of the total system air quantity when subjected to +/- 5" static pressure.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Leak Test: After installation, fill water and hydronic coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Return air and outdoor air damper blades shall be positioned to force these air streams against each other to maximize air mixing and minimize air stratification.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. 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.
5. Verify fan isolators have proper deflection.
6. Verify that outdoor-air and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
7. Comb coil fins for parallel orientation.
8. Install new, clean filters.
9. Verify that manual and automatic volume control and 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.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

A. Clean units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing units and air-distribution systems, clean filter housings and install new filters.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13

SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Wiring Diagrams: For power, signal, and control wiring.

D. LEED Submittals:

1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1.
2. Product Data for Credit EA 4: Documentation indicating that compressor and condenser units and refrigerants comply.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Gaskets: One set(s) for each access door.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: The design is based on the following:

1. Daikin

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
2. LG Air Conditioning Technologies.
3. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
4. SANYO North America Corporation; SANYO Fisher Company.
5. Trane; a business of American Standard companies.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:

1. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
2. Fan: Direct drive, centrifugal.
3. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
d. Mount unit-mounted disconnect switches on exterior of unit.

4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
5. Condensate Drain Pans:

a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.

6. Filters: Cleanable

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.
    b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Charge: R-410A.
    d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Refrigeration Components:

    a. Refrigerant circuit components shall include brass external liquid line service valve with service gage port connections, suction line service valve with service gage connection port, service gage port connections on compressor suction and discharge lines, accumulator, pressure relief, and a full charge of refrigerant.

6. Controls and Safeties:

    a. Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control functions shall include the following:

        1) Controls:

            a) Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
            b) Automatic restart on power failure.
            c) Safety lockout if any outdoor unit safety is open.
            d) A time delay control sequence provided through the fan coil board, thermostat, or controller.
            e) Automatic outdoor-fan motor protection.

        2) Safeties:

            a) System diagnostics.
            b) Compressor motor current and temperature overload protection.
            c) High pressure relief.
            d) Outdoor fan failure protection.

7. Electrical Requirements:

    a. Unit electrical power shall be a single point connection.
    b. Unit control voltage to the indoor-fan coil shall be 24 V.
    c. All power and control wiring must be installed per NEC and all local building codes.

        1) High- and low-voltage terminal block connections.

    d. Accessories:

        1) Low-Ambient Operation:

            a) The control shall be capable of enabling unit operation and start-up with outdoor temperatures to 5 F.
            b) Installation of kit shall not require changing the outdoor-fan motor.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.
5. Automatic changeover from cooling to heating modes

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

1. Minimum Insulation Thickness: 1 inch thick

a. Refer to 23 07 19 for metal jacketing for both exterior refrigeration lines.

2. Provide precharged refrigerant lines that can be oriented to connect to the side or back of unit.

F. Unit shall be furnished with integral wall-mounting bracket and mounting hardware.

G. Drain Hose: For condensate.

H. Outdoor / Mezzanine Level - Unit Support System.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. "Big Foot"; Rector Seal
b. Equivalent as approved.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration Controls for HVAC."

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 REFRIGERANT PIPING SIZING

A. The unit manufacturer shall verify the final refrigeration pipe sizing process to insure conformance to specific unit requirements such as maximum lengths, refrigerant velocities, unloading considerations and proper oil return. This contractor shall provide refrigeration piping drawings from the field which details the way the piping will actually be installed.

3.3 REFRIGERANT PIPING ACCESSORIES

A. Install accessories in accordance with the manufacturer's written instructions and recommendations.

3.4 EQUIPMENT SUPPORT SYSTEM

A. The condensing unit stand shall be mounted free standing either on-grade or the mezzanine floors in a convenient position to facilitate connection of the linesets to the condensing units as well as access for maintenance.

B. Condensing unit stand shall be of modular design to enable the cross members to be lineally adjusted during assembly to accept different configurations of condensing units.

C. Condensing unit stand shall accommodate double decker cross members where space requirements mandate vertical stacking of condensing units.

D. Condensing unit stand shall be fabricated from square steel tubing with a minimum wall thickness of 16 gauge.

E. For loads to a maximum of 660 lbs, cross members shall have a minimum cross section of 1.5" x 1.5".

F. Condensing unit shall be secured to the cross bars with pressed steel clamps which shall be bolted to the cross members.

G. Steel clamps shall allow sufficient space for anti-vibration pads to be fitted under the feet of the condenser.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Ground equipment according to Division 26.

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

E. Division 26 contractor shall provide conduit for both the power and control wiring between the condensing unit and indoor evaporator unit.

F. Provide concrete splash blocks for exterior condensate piping discharge at grade level.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Deliver unit wireless infrared remote controller to Owner with complete set of new batteries.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain split system air conditioning units

END OF SECTION 23 81 26

SECTION 23 82 16.11

HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.3 COORDINATION

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 HEATING COILS

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. Aerofin.
2. Carrier Corporation; a UTC company.
3. Colmac Coil Manufacturing, Inc.
4. Control Air
5. Dunham-Bush USA.
6. Heatcraft Worldwide Refrigeration.
7. Greenheck Fan Corporation.
8. McQuay.
9. RAE Corporation
10. Trane.
11. USA Coil & Air.
12. Wing
13. York

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.

D. Source Quality Control: Factory tested to 300 psig.

E. Tubes: ASTM B 743 copper, minimum 0.025 inch tube wall seamless copper tubes of 5/8 inch maximum outside diameter with maximum of 8 aluminum fins per inch suitable for working pressures to 125 psig and temperatures to 250°F. Coil fins may be the continuous serpentine or plate fin type.

F. Fins: Aluminum, minimum 0.006 inch thick.

G. Headers: Coil headers may be constructed of cast iron, steel, or seamless copper. Where cast iron headers are used, expand tubes into the headers. Where steel or copper headers are used braze tubes to header. Cast iron with drain and air vent tappings or Seamless copper tube with brazed joints, prime coated or Steel with brazed joints, prime coated.

H. 38 expand tubes into the headers. Where steel or copper headers are used braze tubes to header. Provide coils with bronze spring turbulators where required to provide the capacities indicated.

I. Frames: Galvanized-steel channel frame, minimum 0.052-inch-thick for flanged mounting.

J. Hot-Water Coil Capacities and Characteristics: Refer to Schedule on drawings.

K. Provide recessed terminal box when coil installed in ductwork with internally lined insulation to ensure heating elements and safety controls are in air stream.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install coils level and plumb. Straighten bent fins on air coils.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230900 "Instrumentation and Control for HVAC," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties.

D. Install a separate air vent and drain valve for each coil header in such a manner that the vent and drain valves are located outside of air handling unit casing. Provide offsets in piping to facilitate coil removal.

E. For Water coils:

1. For drainage, pitch coils minimum 1/8 inch toward return connections. Install shims, except where coil design includes drainage feature.
2. Level coils and install cleanable and drainable tube water.
3. Support:

    a. Support coil sections on steel channel or double angle frames and secure to casings.
    b. Arrange supports for cooling coils to avoid piercing or short-circuiting drip pans.
    c. Bolt casings to other section, ductwork, or unit casings.
    d. Provide air-tight seal between coil and duct or unit cabinets.

4. Water Supply:

    a. Locate water supply at bottom of coil supply header and return water connection at top to provide self-venting and reverse return arrangement.
    b. Provide air vents at high points complete with stop valve.
    c. Ensure water coils are drainable and make drain connection at low points.

5. Repair or replace coils following purging and tightness testing of coils and piping to eliminate leaks. Retest as specified to demonstrate leakproof performance.

END OF SECTION 23 82 16.11

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SECTION 23 82 16.13

REFRIGERANT AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 REFRIGERANT AIR COILS

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. Aerofin Corporation.
2. Carrier Corporation; a UTC company.
3. Coil Company, LLC.
4. Colmac Coil Manufacturing, Inc.
5. Dunham-Bush, Inc.
6. Greenheck Fan Corporation.
7. Heatcraft Refrigeration Products LLC.
8. Lennox Industries Inc.
9. Super Radiator Coils.
10. Trane.
11. USA Coil & Air.

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure Rating: 300 psig.

D. Source Quality Control: Factory tested to 450 psig.

E. Tubes: ASTM B 743 copper, minimum 0.020 inch thick. Construct coils of minimum 1/2" outside diameter copper tubes with aluminum fins. Test at 250 psig, dehydrate, purge with inert gas, and seal prior to shipment.

F. Coil Split: Interlaced.

G. Fins: Aluminum or Copper, minimum 0.006 inch thick. Continuous serpentine or plate fin type and seamless copper tube in steel casing with equalizing-type vertical distributor.

H. Suction and Distributor Piping: ASTM B 88, Type L copper tube with brazed joints.

I. Frames: ASTM A 666, Type 304 stainless steel, minimum 0.0625-inch-thick for flanged mounting. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

J. Capacities and Characteristics: Refer to Schedules on drawings.

1. Refrigerant Side:

a. Refrigerant Type: R-410A.

K. Provide recessed terminal box when coil installed in ductwork with internally lined insulation to ensure heating elements and safety controls are in air stream.

L. All safety devices shall be serviceable without removing coil.

M. Cooling coils shall be sized and arranged to prevent moisture carryover. Cooling coils shall be sized for a maximum of 500 FPM face velocity. If two or more coils are stacked in the unit, intermediate drain channels shall be installed between coils to drain condensate to the main drain pans without flooding the lower coils or passing condensate through the airstream of the lower coil.

N. Support coils along their entire length within the cabinet and pitch for proper drainage.

O. Provide factory installed modulating hot gas reheat coils with AHU-A1 and AHU-E1 located on the leaving air side of the evaporator coil. Copper Tube, aluminum fin coil assembly with modulating control. Refer to the Sequence of Operations section of the Installation, Operation and Maintenance manual for detailed unit control and operational modes.

1. Hot gas reheat coil includes aluminum tube micro channel design with high efficiency brazed aluminum fins for direct bonding and provides better heat transfer.
2. Modulating hot gas reheat is comprised of a parallel coil arrangement, with dual modulating reheat valves (which operate in concert with one another) and a check valve.

2.3 COIL HOUSING

A. Housing: Each cooling coil shall be factory assembled into a double wall, insulated housing. Housing shall have 24-gauge 304 stainless steel inner wall and drain pan, 16 gauge galvanized steel outer wall, and 2 inches thick of 1½ lb. density fiberglass insulation. Housing shall have removable access pane for cooling coil removal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install refrigerant specialties as detailed and in accordance with manufacturer's instructions. Provide offsets in piping to facilitate coil removal.

C. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Install stainless-steel drain pan under each cooling coil and hot gas reheat coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

E. Install condensate drain trap with proper depth from each cooling coil condensate drain to the nearest drain location.

F. Contractor to make sure there is sufficient depth below air handling unit cooling coils to obtain the proper depth of trap; spring vibration isolators or housekeeping pads will not provide sufficient height

G. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

H. Straighten bent fins on air coils.

I. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

END OF SECTION 23 82 16.13

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SECTION 23 82 19

FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

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. Field quality-control reports.

D. CLOSEOUT SUBMITTALS

E. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

a. Maintenance schedules and repair part lists for motors, coils and filters.

1.3 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. Fan Coil Unit Filters: Furnish one spare filters for each filter installed.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Compressor failure.
b. Condenser coil leak.

2. Warranty Period: Four years from date of Substantial Completion.
3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTED FAN COIL UNITS (SPLIT SYSTEM)

A. Basis-of-Design Product: The design is based on the following:
1. Aaon Inc.

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:
1. Addison Corporation
2. Carrier Corporation; a UTC company.
3. ENVIRO-TEC; by Johnson Controls, Inc.
4. Greenheck Fan Corporation.
5. Daikin/ McQuay International
6. Liebert Corporation
7. Valent
8. YORK; by Johnson Controls, Inc.

C. Fan Coil Unit Configurations: Face split.
1. Number of DX Cooling Coils: One with refrigeration pipe system for FCU-A1, D1 and D2.
2. Number of Heating Coils: One with electric-resistance heating coils for FCU-D1 and D2.
3. Number of Hot Gas Reheat Coil: One with refrigeration pipe system for FCU-D1 and D2.

D. Coil Section Insulation: Minimum 1-inch-thick, closed cellular foam insulation or foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.

G. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.

H. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis.

I. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

J. MERV Rating: 7 when tested according to ASHRAE 52.2.

1. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.
2. 2 inch media.

K. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

L. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

M. Refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

N. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware. Provide SCR controls for electric-resistance heating coils.

O. Direct-Driven Fans: Backward curved plenum; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels and painted-steel or galvanized-steel fan scrolls.

P. ECM motor ECM electronically commutated motor system is a single or three-phase motor for continuously variable speed control for exhaust fans for motors less than 2 HP.
1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

Q. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping."

R. Air-Cooled, Compressor-Condenser Unit:

1. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed scroll type.
    a. Crankcase heater.
    b. Vibration isolation mounts for compressor.
    c. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    d. Single stage compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
    e. Refrigerant: R-410A.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F.
7. Mounting Base: Polyethylene.

S. Electrical Connection: Factory wire motors and controls for a single electrical connection with factory wired to disconnect switch located on outside of fan housing.

T. Controls:

1. DDC Controls are specified in Section 230924 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

U. Capacities and Characteristics: Refer to Schedule on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration Controls for HVAC."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

F. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

G. Clean dust and debris from each unit as it is installed. Comb out damaged fins where bent or crushed before covering elements with enclosures.

H. CONNECTIONS

I. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

J. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect refrigeration piping to fan coil unit.
3. Connect condensate drain to indirect waste.
4. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

K. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

L. Install thermometer at each side of both supply and return air streams.

M. Install pressure gauge equal to Dwyer Series 2000 Magnehelic across unit in supply air stream.

N. Electrical: Comply with applicable requirements in Division 26.

O. Ground equipment according to Division 26.

P. Connect refrigerant piping to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.
1. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

Q. Comply with requirements in Section 232300 "Refrigerant Piping" for installation and joint construction of refrigerant piping.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. 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 safety devices. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust initial temperature and humidity set points

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-to-air energy recovery system testing, adjusting, and balancing

3.5 CLEANING

A. Clean units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and fixed plate core entering air face.

B. After completing system installation and testing, adjusting, and balancing units and air-distribution systems, clean filter housings and install new filters.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 23 82 19

SECTION 23 82 39.19

WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. 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.

D. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

A. Basis-of-Design Product: The design is based on the following:

1. Modine

B. Subject to compliance with requirements, provide the named product or a comparable product by one the following:

1. Airtherm; a Mestek Company.
2. Dunham-Bush, Inc.
3. McQuay International
4. Rittling

5. Sterling
6. Trane.
7. Vuclan

2.2 DESCRIPTION

A. Description: An assembly including casing, coil, fan, and motor in vertical discharge configuration with adjustable discharge louvers.

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. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33

2.3 CABINET

A. 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.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

D. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4 COILS

A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

2.5 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

B. Motor: Permanently lubricated. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

A. Controls: Unit-mounted thermostat.

1. Built-in fan delay switch.

B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

C. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

2.7 CAPACITIES AND CHARACTERISTICS

A. Wall and Ceiling Unit Heater: Refer to Schedule on the drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall 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.

A. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration Controls for HVAC."

B. Ground equipment according to Division 26 Connect wiring according to Division 26.

A. Connect wiring according to Division 26.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Clean dust and debris from each unit as it is installed. Comb out damaged fins where bent or crushed before covering elements with enclosures.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and ball valve on supply-water connection and union and (PICCV) calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain unit heaters.

END OF SECTION 23 82 39.19

SECTION 23 83 16

RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes radiant-heating piping, including pipes, fittings, and piping specialties.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PEX: Crosslinked polyethylene.

C. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.
2. Provide product data for injection pumps and control valves

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: 1/4 inch = 1 foot.
2. Drawing(s) shall show proof of review and approval by radiant floor heating system manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's standard twenty (20) year warranty on tubing.

B. Manufacturer's standard thirty-six (36) month warranty on manifolds and other auxiliary components.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Manufacturer Basis-of-Design Product: The design is based on the following:

1. Uponor- Radiant Rollout Mat.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. REHAU Incorporated.
2. Heatlink.
3. Watts Radiant, inc.; a Watts Water Technologies company.

C. Alternate for Roth XPert S5 or DuoPex S5- Pex C or may be substituted from the manufacturers listed in the following sections provided the materials of construction equal the basis of design, and the layout and scheduled performance is maintained. Final approval of substitutions will be determined by Architect/Engineer.

1. Roth XPert S5 with EVERLOC® Fitting System
2. Roth DuoPex S5 or Pex C

D. Pipe Material: PEX plastic according to ASTM F 876, PEX A.

E. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.

F. Fittings: ASTM F 1807, metal insert and copper crimp rings for cold expansion fittings with reinforcing rings.

1. Uponor ProPEX® Fitting System
2. Sioux Chief PowerPEX™ F1960 Fitting System

G. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F.

2.2 DISTRIBUTION MANIFOLDS

A. Manifold: Minimum NPS 1, brass or stainless steel.

B. Main Shutoff Valves:

1. Mount on supply and return connections.
2. Shut-off valves are specified in Section 230523 - “General-duty valves for HVAC Piping.”

C. Manual Air Vents:

1. Mount on supply and return connections.
2. Manual air vents are specified in Section 232116 – “Hydronic Piping Specialties.”

D. Balancing Valves:

1. Mount on return connections.
2. Balancing valves are specified in Section 232116 – “Hydronic Piping Specialties.”

E. Zone Control Valves:

1. Temperature-control devices and sequence of operations are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

F. Mounting Brackets: Copper, or plastic- or copper-clad steel, where in contact with manifold.

2.3 PIPING SPECIALTIES

A. Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch.
3. Tensile Strength: 20 lb. minimum.
4. Temperature Range: Minus 40 to plus 185 deg F.

B. Floor Mounting Staples:

1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch.
3. Width: Minimum, wider than tubing.

C. Floor Mounting Clamps:

1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch.
3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:

1. Aluminum or plastic channel track with smooth finish and no sharp edges.
2. Minimum Thickness: 1/16 inch.
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: 2-inch intervals.
5. Rehau “Octa Rail” or equivalent

2.4 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
2. Ensure that surfaces and substrates are level and plumb.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following types of radiant-heating piping for the applications described:

1. Piping in Interior Reinforced-Concrete Floors: PEX.

3.3 PRE-INSTALLATION MEETING

A. 45 days prior to beginning of the installation of radiant heating hydronic piping, the contractor shall conduct a meeting with the Architect/Engineer, Owner’s Project Representative, Commissioning Provider (CxP) and the mechanical system and temperature control system installing Contractors. Provide AE and CxP with a complete copy of the radiant piping system; product data and shop drawings for the project. The objective is final coordination and verification of system operation and readiness for installation procedures and scheduling procedures with the above

mentioned parties. Indicate work required to be completed prior to installation and identify the party responsible for completion of that work.

3.4 INSTALLATION

A. Engage a factory-authorized service representative to perform field inspections for installation of radiant heating hydronic piping. Install Uponor “Roll-Out” mats per manufacturer’s requirements.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

C. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

1. If a fitting must be installed in the concrete slab it must be protected with a HDPE shrink sleeve as recommended by the manufacturer and must be approved by the engineer.

D. Contractor shall install the product “Octa Rail” or equivalent for securing Pex tubing to board insulation. fastened to insulation every 3 to 5 ft. using appropriate pins or nails. PEX tubing snaps easily into the pre-cut Rail grooves. Rail length is 3.4 feet and 1.25-inch high. Connect radiant piping to manifold in a reverse-return arrangement.

E. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.

F. Install manifolds in accessible locations or install access panels to provide maintenance access as required in Division 08 "Access Doors and Frames."

G. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

H. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Division 07 "Penetration Firestopping."

I. Piping in Interior Reinforced-Concrete Floors:

1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of 18 inches o.c. and at center of turns or bends.
3. Maintain 2-inch minimum cover.
4. Install a sleeve of 3/8-inch-thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig pressure in piping during concrete placement and continue for 24 hours after placement.

J. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

K. After system balancing has been completed, mark balancing valves to permanently indicate final position.

L. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

M. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F above the ambient radiant-panel temperature and increase 10 deg F each following day until design temperature is achieved.
2. For freeze protection, operate at a minimum of 60 deg F supply-water temperature.

N. Maximum loop lengths shall be:

1. 5/8" diameter tubing: 500 ft.
2. 3/4" diameter tubing: 500 ft.

O. Tubing connections shall be made with compression fittings supplied by manufacturer. Fittings from other sources are not acceptable.

P. Extend power wiring from fused disconnect to electrical junction box on unit.

1. Install thermostat or sensor in indicated location, provide line or low voltage wiring from thermostat to electrical junction box on unit.
2. Comply with Division 16 specifications for wiring.

Q. All fittings shall be accessible for maintenance.

R. Acceptable tube spacing: 6" to 9" O.C.

1. When underfloor tubing is routed adjacent to an exterior wall having an excess of 30% glass area, tubing spacing shall be 6" o.c. within 12" of exterior wall.

S. When installing the tubing the joint must be made immediately or capped with tape to seal the tube from contaminants.

T. All circuits will be labeled and marked as supply and return. The contractor will submit a record of actual tube circuit length for final balancing purposes.

3.5 FIELD QUALITY CONTROL

A. Prepare radiant-heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.
3. Flush with clean water and clean strainers.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.

END OF SECTION 23 83 16

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SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to all Sections of divisions 26, 27, and 28.

1.2 DESCRIPTION

A. Work to be performed under the sections of Divisions 26, 27, and 28 includes all labor, materials, and equipment required to install complete electrical systems as described in these specifications and as shown on the drawings. This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections.

B. Before submitting a bid, the Contractor shall examine the drawings and specifications, visit the work site, and be informed of local conditions, all federal, state and local ordinances, regulations and all other pertinent items which may affect cost, schedule, and completion of this project.

C. Drawings accompanying these specifications are a part of these specifications. Drawings are intended to show general arrangement, design, and extent of work and are diagrammatic. Drawings are not intended to show exact locations except where dimensions are shown. Any substantial differences existing between drawings and conditions in the field shall be submitted to the Engineer for consideration before proceeding with work. Electrical work is shown on plans using standard industry symbols.

D. Before ordering materials or doing work, the Contractor shall verify all measurements pertaining to work scope and assume installation responsibility for complete and fully functional electrical systems.

E. The electrical work included in all other divisions of this specification and related documents is the responsibility of the contractor performing the division 26, 27, and 28 work unless specifically noted otherwise.

1.3 REFERENCED STANDARDS

A. Abbreviations of standards organizations referenced in this and other sections are as follows:

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.	IBC	International Building Code
6.	IEEE	Institute of Electrical and Electronics Engineers
7.	IES	Illuminating Engineering Society
8.	ISA	Instrument Society of America
9.	NBS	National Bureau of Standards
10.	NEC	National Electric Code
11.	NECA	National Electrical Contractors Association

12.	NEMA	National Electrical Manufacturers Association
13.	NESC	National Electrical Safety Code
14.	NFPA	National Fire Protection Association
15.	UL	Underwriters Laboratories Inc.

1.4 QUALITY ASSURANCE

A. Manufacturer references used herein are intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

B. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space and for obtaining the performance from the system into which these items are placed.

C. All materials shall be listed by and shall bear the label of an approved electrical testing laboratory. If none of the approved electrical testing laboratories has published standards for a particular item, then other national independent testing standards, subject to approval by the Engineer, shall apply and such items shall bear those labels. Where one of the approved electrical testing laboratories has an applicable system listing and label, the entire system shall be so labeled. The Contractor shall not modify new equipment in such a way as to nullify the Testing Laboratories label. All equipment and materials shall be used or installed in accordance with any instruction included in the listing by the laboratory.

1.5 DEFINITIONS

A. Activation: Nomenclature used by some manufacturers for a service fitting.

B. ARC: Aluminum rigid conduit.

C. ATS: Acceptance Testing Specifications.

D. BACnet: A networking communication protocol that complies with ASHRAE 135.

E. BAS: Building automation system.

F. BF: Ballast factor.

G. CCT: Correlated color temperature.

H. CE: Conformite Europeene (European Compliance).

I. CPT: Control power transformer.

J. CRI: Color-rendering index.

K. CV: Coefficient of variation; a statistical measure of the weighted average of all relevant illumination values for the playing area, expressed as the ratio of the standard deviation for all illuminance values to the mean illuminance value.

L. Data Bus: Two wires used to communicate with bus connected devices.

M. Delegated-Design Submittals: Documents, including drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by Owner and authorities having jurisdiction.

N. Device: A collective term for DALI-compliant bus connected devices, including fluorescent ballasts, incandescent fixtures, manual switches, switching relays, and similar. Sometimes also known as "slave unit."

O. ETFE: Ethylene tetrafluoroethylene.

P. EMI: Electromagnetic interference.

Q. EMT: Electrical metallic tubing.

R. Ethernet: Local area network based on IEEE 802.3 standards.

S. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

T. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.

U. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

V. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.

W. FEP: Fluorinated ethylene propylene.

X. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

Y. FMG: Factory Mutual Group

Z. GFCI: Ground-Fault Circuit Interrupter.

AA. GRC: Galvanized rigid steel conduit.

BB. Group: A set of devices that respond at the same time to messages on the data bus.

CC. HTML: Hypertext markup language.

DD. IBC: International Building Code.

EE. ICC-ES: ICC-Evaluation Service.

FF. IGBT: Insulated-gate bipolar transistor.

GG. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.

HH. Horizontal Illuminance: Measurement in foot-candles, on a horizontal surface 36 inches above ground unless otherwise indicated.

II. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.

JJ. Vertical Illuminance: Measurement in foot-candles, in [**two**][**four**] directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.

KK. IMC: Intermediate metal conduit.

LL. Inominal: Nominal discharge current.

MM. Interruptible: As used in the Section Text, an off-line, passive-standby or line-interactive, inverter-only unit, with an intentional interruption of power to the load until an internal transfer switch picks up and transfers the load to the unit's inverter and internal battery source on loss of the "normal" source, and then retransfers to the "normal" source when it is restored. Transfer time can be "slow" (up to approximately 1 second) or "fast" (2-4 ms or 40-50 ms, depending on manufacturer).

NN. I/O: Input/output.

OO. IP: Internet protocol.

PP. IP Code: Required ingress protection to comply with IEC 60529.

QQ. IR: Infrared.

RR. Jacket: A continuous nonmetallic outer covering for conductors or cables.

SS. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

TT. LAN: Local area network; sometimes plural as "LANs."

UU. LC: Lighting Certified.

VV. LCD: Liquid crystal display.

WW. LED: Light-emitting diode.

XX. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

YY. LER: Luminaire efficacy rating.

ZZ. Light Trespass: Light spill into areas and properties outside the playing areas, which is either annoying or unwanted.

AAA. LLD: Lamp lumen depreciation, which is the decrease in lamp output as the lamp ages.

BBB. LLF: Light loss factor, which is the product of all factors that contribute to light loss in the system.

CCC. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

DDD. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

EEE. LP: Liquid petroleum.

FFF. Lumen: Measured output of lamp and luminaire, or both.

GGG. Luminaire: Complete lighting fixture, including ballast housing if integral.

HHH. Maximum Power Point Tracking (MPPT) Control: MPPT software control of inverter in a renewable

energy system allows the ac output power to be proportional to the dc input voltage.

III. MCC: Motor-control center.

JJJ. MCCB: Molded-case circuit breaker.

KKK. MCOV: Maximum continuous operating voltage.

LLL. MCP: Motor-circuit protector.

MMM. Modbus TCP/IP: An open protocol for exchange of process data.

NNN. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

OOO. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

PPP. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

QQQ. MPPT: Maximum power point tracking.

RRR. Maximum Power Point Tracking (MPPT) Control: MPPT software control of inverter in a renewable energy system allows the ac output power to be proportional to the dc input voltage.

SSS. NC: Normally closed.

TTT. NETA ATS: Acceptance Testing Specification.

UUU. NiCd: Nickel cadmium.

VVV. NO: Normally open.

WWW. OCPD: Overcurrent protective device.

XXX. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

YYY. 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.

ZZZ. OSHPD: Office of Statewide Health Planning and Development for the State of California.

AAAA. PC: Personal computer; sometimes plural as "PCs."

BBBB. PCC: Point of common coupling.

CCCC. PID: Control action, proportional plus integral plus derivative.

DDDD. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

EEEE. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

FFFF. Pole: Luminaire support structure, including tower used for large area illumination.

GGGG. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.

HHHH. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

IIII. PT: Potential transformer.

JJJJ. PTC: USA standard conditions for PV.

KKKK. PV: Photovoltaic.

LLLL. PWM: Pulse-width modulated.

MMMM. RFI: Radio-frequency interference.

NNNN. RMC: Rigid metal conduit.

OOOO. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

PPPP. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

QQQQ. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A

RRRR. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

SSSS. SCR: Silicon-controlled rectifier.

TTTT. SCCR: Short-circuit current rating.

UUUU. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

VVVV. Sheath: A continuous metallic covering for conductors or cables.

WWWW. SPD: Surge protective device.

XXXX. SPDT: Single pole, double throw.

YYYY. Standard: Same definition as "Pole" above.

ZZZZ. STC: Standard Test Conditions defined in IEC 61215.

AAAAA. SVR: Suppressed voltage rating.

BBBBB. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

CCCCC. TDD: Total demand (harmonic current) distortion (also listed as "THD" in catalog data by manufacturers).

DDDDD. THD: Total harmonic distortion.

EEEEE. THD(V): Total harmonic voltage demand.

FFFFF. Tip-Speed Ratio (TSR): The ratio between the wind speed and the speed of the tips of the wind turbine blades. The tip speed of a turbine is calculated by manufacturer based on rated wind speed. The radius of the rotor's swept area is multiplied by two times Pi (3.1415) and divided by the rated time to complete one complete rotation.

GGGGG. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

HHHHH. TVSS: Transient voltage surge suppressor.

IIIII. UG: Uniformity gradient; the rate of change of illuminance on the playing field, expressed as a ratio between the illuminances of adjacent measuring points on a uniform grid.

JJJJJ. Uninterruptible: As used in the Section Text, an on-line, double-conversion (rectifier/inverter) unit, with no interruption of power to the load on interruption and restoration of the "normal" source.

KKKKK. UPS: Uninterrupted power supply.

LLLLL. UTP: Unshielded twisted pair.

MMMMM. VFC: Variable-frequency motor controller.

NNNNN. VFD – Variable frequency drive or motor controller.

OOOOO. VPN: Virtual private network.

PPPPP. VPR: Voltage protection rating.

QQQQQ. VRLA: Valve-regulated lead acid.

RRRRR. WAN: Wide area network.

SSSSS. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.6 REGULATORY REQUIREMENTS

A. All work and materials are to conform in every detail to applicable rules and requirements of local codes and regulations, the National Electrical Code (NFPA 70), other applicable National Fire Protection Association codes, and current manufacturing standards (including NEMA) and any additional local modifications enacted by the Local Authority Having Jurisdiction. Contractor shall be responsible to verify what if any local modifications are in place or enacted by the Local Authority Having Jurisdiction.

B. All work shall be installed in accordance with NECA standards of installation.

C. All work shall conform where applicable to the Williams-Steiger Occupational Safety and Health Act of 1970 (OSHA), Part 1910, “Occupational Safety and Health Standards.” This shall include any local or state modifications enacted by the Authority having Jurisdiction.

1.7 OMISSIONS

A. No later than ten (10) days before bid opening, the Contractor shall call to the attention of the Engineer any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.8 SUBMITTALS

A. Refer to Division 01 for Submittal requirements.

B. Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name or number, as indicated in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor for correction and resubmission. Failing to follow these instructions does not relieve the Contractor from the requirement of meeting the project schedule.

C. On request, the Contractor shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc. to clarify intent of construction or operations.

D. Submittals shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams of electrically powered equipment.

E. The submittals must be approved before fabrication.

1.9 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.

B. Prepare drawings showing proposed rearrangement of work to meet Project conditions, including changes to work specified in other Sections. Obtain written permission of Engineer before proceeding.

C. Tools, materials, and equipment shall be confined to areas designated by the Construction Manager.

1.10 WORK SEQUENCE AND SCHEDULING

A. See the General Conditions of the Contract, Scheduling and Coordination of Work, and Time for Completion of the Project, and General Requirements, Mutual Responsibility for additional requirements.

1.11 WORK BY OTHER TRADES

A. Every attempt has been made to indicate in this trade's specifications and drawings all work required of this Contractor. However, there may be additional specific paragraphs in other trade specifications and addenda, and additional notes on drawings for other trades which pertain to this Trade's work, and thus those additional requirements are hereby made a part of these specifications and drawings.

B. Electrical details on drawings for equipment to be provided by others is based on preliminary design data only. This Contractor shall lay out the electrical work and shall be responsible for its correctness to match equipment actually provided by others.

1.12 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Refer to Division 1, General Requirements, Operating and Maintenance Instructions for additional requirements.

1.13 TRAINING

A. Instruct Owner’s personnel in the proper operation and maintenance of systems and equipment provided as part of this project; video record all training sessions. Use the Operating and Maintenance manuals during this instruction. Demonstrate startup and shutdown procedures for all equipment. All training to be during normal working hours.

B. The requirement for recording training sessions may be deleted on some projects but not the requirement for the training itself.

C. Refer to other sections in Divisions 26, 27, and 28 for specific section and equipment training requirements.

1.14 RECORD DRAWINGS

A. A set of prints shall be kept at the job site upon which all changes and deviations from the original design are to be recorded daily. All changes shall be clearly marked. These drawings shall indicate as a minimum, all changes made to the drawings, changes in circuiting, equipment location, accurate locations of embedded conduit, and all other significant changes and deviations from the original design.

B. The daily record of changes shall be the responsibility of the Contractor's field representative. No arbitrary mark-ups will be permitted.

C. At the completion of the project, the Contractor shall submit the marked-up record drawings to the Owner prior to request for final payment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Reference applicable sections within Divisions 26, 27, and 28.

PART 3 - EXECUTION

3.1 WORK INCLUDED

A. The scope of work shall include all work, including all labor, materials and equipment, testing required to install a complete electrical system as indicated in the project Manual. The Project Manual consists of the bidding documents, the contract, specifications, contract drawings and all subsequent addenda and modifications. The contractor shall furnish and install all necessary materials, apparatus and devices to complete the electrical equipment and systems installation herein specified, except such parts as are specifically exempted herein.

B. All work items shown on the drawings is within the scope of work and shall be provided as indicated. Only items that are clearly indicated as being provided by others or under a separate contract shall be out of scope.

C. In general, the specifications indicate the requirements and quality for products required and the executions for those products. Only items that are clearly indicated as being provided by others or under a separate contract shall be out of scope.

D. If there is any discrepancy between the drawings and the specifications, it is the contractor's responsibility to notify the Engineer for resolution, prior to procuring equipment or starting work.

E. Coordinate and verify all equipment being supplied by equipment supplier and other trades. Verify equipment size, motor HP, dimensions, locations, etc. as all are subject to change.

F. Contractor shall verify all door swings and the location of all cabinets, diffusers, HVAC, plumping, process and building equipment before installing electrical equipment, fixtures, outlets and conduit.

G. The Contractor shall provide all plywood backboards and supports for all electrical equipment as indicated on the drawings and as required or specified.

H. All permits and inspection fees required to complete the work shall be paid for by the Contractor unless noted otherwise.

I. All electrical equipment and fixtures shall be installed in complete accordance with the manufacturers' recommendations.

J. Contractor shall provide all motor connections as shown on the drawings and as specified herein.

3.2 CONCRETE

A. All concrete work required for the proper installation of electrical equipment including transformer, switchgear and motor control center pads and other equipment pads shall be provided by the Contractor and shall conform to specifications in Division 3.

3.3 SITE WORK

A. The Contractor shall provide excavation and backfill for all electrical underground work as indicated on the drawings and as required. The Contractor shall perform this work and provide compaction as specified in Division 2. Finish grading and final restoration shall be by the General Contractor.

3.4 BUILDING ACCESS

A. Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

3.5 EQUIPMENT ACCESS

A. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Where access is required in plaster or drywall walls or ceilings, furnish the access doors to the General Contractor and reimburse the General Contractor for installation of those access doors.

3.6 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, provided such decision is reached prior to actual installation. The Contractor shall check location of electrical outlets with respect to other installations before installing.

B. The Contractor shall verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, light fixtures, panelboards, devices, etc. and recessed or semi-recessed heating units installed in/on architectural surfaces.

C. Coordinate all work with other trades prior to installation. Any installed work that is not coordinated and that interferes with another trades work shall be removed or relocated at the installing contractor's expense.

3.7 HOUSEKEEPING AND CLEAN UP

A. Refer to Division 1, General Requirements, and Cleaning for additional requirements.

B. The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, the Contractor shall remove all tools, excess material and equipment, etc., from the site.

END OF SECTION 26 05 00

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Wire and cable routing where shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.

B. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   1. Alcan Products Corporation; Alcan Cable Division.
   2. American Insulated Wire Corp.
   3. General Cable Corporation.
   4. Senator Wire & Cable Company.
   5. Southwire Company.
   6. AFC Cable Systems, Inc.

B. Aluminum and Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN/THWN, XHHW-2 and SO.

D. Multi-conductor Cable: Comply with NEMA WC 70 for Type SO with ground wire.

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.
6. Thomas & Betts.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

C. Spring wire connectors: Corrosion-resistant, live-action spring in insulated shell, rated 105°C.

D. Connectors and lugs: Circumferential compression (non-indenter) type.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Conductor: Copper or aluminum for feeders 100 Amps and larger. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
2. Insulation: Type XHHW-2 insulation for feeders larger than #2 AWG; Type THHN/THWN insulation for feeders #2 AWG and smaller.
3. Special Requirements for Aluminum Conductors

    a. It is the responsibility of the contractor to increase the size of the conduit, wire gutter, or enclosure, if necessary, to accommodate the aluminum conductors and meet allowable code requirements.
    b. It is the responsibility of the contractor to increase the size of the aluminum conductor to match the ampacity of the copper conductor circuit shown on the Drawings.
    c. The contractor shall submit a feeder schedule to the Engineer for all conductor substitutions indicating the aluminum conductor wire size and the conduit size. The contractor shall not begin the installation until written approval is granted by the Engineer.

B. Branch Circuits:

1. Conductor: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
2. Insulation: Type XHHW-2 insulation for branch circuits larger than #2 AWG; Type THHN/THWN insulation for branch circuits #2 AWG and smaller.
3. Motors and equipment connections subject to vibration: Copper. No. 12 AWG and larger, stranded conductor, single conductor.
4. Use stranded conductor, single conductor, No. 14 minimum for control wiring.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Single conductors in raceway.

B. Exposed Feeders: Single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Single conductors in raceway.

E. Branch Circuits Concealed above Ceilings, in Walls, and Partitions: Single conductors in raceway.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Single conductors in raceway.

G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

H. Class 1 Control Circuits: Single conductors in raceway.

I. Class 2 Control Circuits: Single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, above ceilings, and in floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed conduits parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Neatly train and lace wiring inside boxes, equipment, and panelboards.

F. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

G. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 FEEDER REQUIREMENTS

A. Contractor shall provide lugs, compression fittings, auxiliary wireways, etc., of adequate size for termination of feeder sizes as indicated on drawings. Feeder sizes indicated may be oversized for voltage drop in some cases. Contractor shall coordinate with equipment manufacturer for proper lug sizes.

B. Extend feeders at full capacity from origin to termination.

C. Feeders shall be continuous, without splices in so far as, practical. All feeder splices not specifically indicated on drawings must be prior approved by engineer in writing before splicing any cable.

D. Each conduit raceway shall contain only those conductors constituting a single feeder circuit.

E. Where multiple raceways are used for a single feeder, each raceway shall contain a conductor of each phase and neutral, if used, and a grounding conductor.

F. Where feeder conductors are run in parallel, conductors shall be of same length, same material, circular-mil area, insulation type, and terminated in same manner.

G. Where parallel feeder conductors are run in separate raceways, raceways shall have same physical characteristics.

H. Feeders shall follow most accessible routes, concealed in construction in finished areas, exposed to the minimum temperature gradient and to minimum temperature fluctuation.

I. Confine feeders to insulated portions of building, unless otherwise shown.

J. Trapped runs without facilities for continuous drainage are not acceptable.

K. Do not draw conductors into conduits until building is enclosed and watertight and until work which may cause cable damage has been completed.

L. Feeders shall be sized for a maximum voltage drop of 2%.

3.5 BRANCH CIRCUIT REQUIREMENTS

A. Do not use wire smaller than No. 12 AWG (unless otherwise noted) for branch circuit wiring, including motor circuits. All 20 amp, 120 volt and 277 volt branch circuit homeruns (to panelboard) serving receptacles, equipment, and lighting shall be No. 10 AWG minimum to first outlet or light fixture.

B. Size home runs for 120V branch circuits based on the overall circuit length to the furthest outlet. The following requirements shall be followed:

1. 0 to 100 ft. circuit length: Size home run at #10 AWG minimum to first outlet.
2. 101 to 150 ft. circuit length: Size home run at #8 AWG minimum to first outlet.
3. 151 to 250 ft. circuit length: Size home run at #6 AWG minimum to first outlet.
4. For other branch circuits, size conductors so that voltage drop does not exceed 3%.

C. All 120 volt and 277 volt branch circuits shall have a dedicated neutral conductor for each circuit.

D. The plans show a circuit number for each device or light. This is done for clarity. No more than three 120V or 277 circuits shall be allowed in a single home run raceway.

E. Any branch circuit protected by a GFCI circuit breaker shall be provided with a dedicated neutral conductor.

3.6 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 and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

D. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

E. Clean conductor surfaces before installing lugs and connectors.

F. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

G. Use compression connectors for conductor splices and taps, 6 AWG and larger. Use compression tool designed for the size and type of connector being compressed. Tape uninsulated conductors and connector with electrical tape to 150% of insulation rating of conductor.

H. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 8 AWG and smaller.

I. Where oversized conductors are called for (due to voltage drop, etc.) provide/install lugs as required to match conductors, or provide/install splice box, and splice to reduce conductor size to match lug size.

3.7 MOTOR AND EQUIPMENT WIRING

A. Furnish and install motor circuits in accordance with schedules on drawings and code requirements, from source of supply to associated motor starter, and from starter to motor terminal box, including necessary and required intermediate connections.

B. Conductor and conduit size for motor branch circuits, if shown on drawings, are sized for motor requirement only. Contractor may, at his option, include associated control conductors in same conduit providing the conduit size is adjusted to meet code requirements for percentage of fill.

C. Motors shall have proper size wire as per applicable codes and nameplate ratings. Verify ratings of motors before installing wiring.

D. Obtain manufacturer's wiring diagrams of electrical equipment furnished with equipment and do not proceed to wire equipment without this information.

E. Before installing raceways and pulling wire to any mechanical equipment, verify electrical characteristics with final submittal on equipment to assure proper number and AWG of conductors. (As for multiple speed motors, different motor starter arrangements, etc.).

F. Make equipment connections with flexible conduit or liquid-tight flexible metallic conduit. Properly ground non-current carrying metal parts of equipment. Where cord connections or receptacles are required, provide type "S" rubber jacketed cord, 600 volt, heavy duty service of sizes and lengths required, and receptacle as applicable.

G. Coordinate work with the other trades such that the operation of mechanical equipment will be as described in mechanical specifications.

H. Unless otherwise indicated on drawings or in specifications, motors shall be furnished, set in place, and connected to driven equipment and prepared for operation as specified in other sections. Provide final connection and proper phase relationship to achieve proper motor rotation.

3.8 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 Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.9 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors.
2. Visual and Mechanical Inspection

    a. Compare cable data with drawing and specifications
    b. Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.
    c. Inspect bolted electrical connections for high resistance. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
    d. Inspect compression-applied connectors for correct cable match and indentation.
    e. Inspect for correct contractor identification and phase arrangements.
    f. Inspect jacket insulation and condition.

3. Electrical Tests:

    a. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.
    b. Perform continuity tests to insure correct cable connection.

4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
    d. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

A. This Section includes methods and materials for grounding systems and equipment, plus the following special applications:

1. Common ground bonding with lightning protection system.

1.3. ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4. INFORMATIONAL SUBMITTALS

A. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For qualified testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5. CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS.

a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
b. Include recommended testing intervals.

2. NFPA 99 grounding test results for patient care areas.

1.6. QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of 1/4 inches annealed copper, minimum 4 by 20 inches in main electrical rooms and minimum 4 by 10 inches in all other areas, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Panduit: Irreversible compression connectors.
2. Erico: Welded connectors.

B. Listed and labeled by a NRTL acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

C. Bolted Connectors for Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

D. Welded Connectors: Exothermic-welding kits, low-emission, electric-starting types and of types recommended by kit manufacturer for materials being joined and installation conditions.

E. Compression Connectors: Irreversible type meeting IEEE standard 837-2002 and UL listed.

F. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.01 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4-inch diameter by10 feet.

B. Grounding Test Wells:

1. Well Pipe: 8-inch by 24-inch-long pipe with belled end.
2. Well Cover: Cast iron with legend "GROUND" embossed on cover. Provide bolted, traffic rated cover.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.

C. Grounding Bus: Install in all electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus bar on insulated spacers 1 inch, minimum, from wall 18 inches above finished floor, unless otherwise indicated.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors.
3. Connections to Ground Rods at Test Wells: Welded connectors.
4. Connections to Structural Steel: Welded connectors.
5. Aboveground Accessible Connections: Irreversible compression or welded connectors.
6. Connections in areas that may be a fire hazard to use welded connectors: Irreversible compression connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. Terminate each end on suitable lug, bus or bushing.

B. Bond equipment grounding terminal bars of the normal and emergency electrical system panelboards that serve the same patient area with an insulated continuous copper conductor not smaller than 8 AWG.

C. Provide grounding and bonding in patient care areas to meet requirements of NFPA 99 and Regulatory Requirements.

D. Bond fuel storage tanks and associated metallic piping systems to building ground system.

E. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide insulated grounding conductor in raceway (minimum 4 AWG) from the main service copper bus bar to each service location(s), terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a copper grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
3. Bond all cable tray, metallic conduits, and equipment racks with minimum 6 AWG to copper bus bar.

3.3 INSTALLATION

A. Install Products in accordance with manufacturer's instructions and NECA 331.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

D. Ground Rods: Drive rods until tops are 12 inches 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.

E. Test Wells: Install at each ground rod. Set top of test well flush with finished grade or floor.

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 any adjacent parts. Bond together metal siding not attached to grounded structure and bond to grounding electrode system.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

H. Grounding and Bonding for dry type transformers:

1. Step-down transformer secondaries shall be grounded to the nearest electrical room ground bus bar. Also, bond the grounded conductor of the transformer to the nearest available point of the interior metal water piping system in the area served by the transformer in accordance with NEC Article 250-104.

I. Grounding for Steel Building Structure:

1. Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
2. Install insulated copper grounding conductor in conduit from main electrical service copper bus bar to building structural steel.

J. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel unless noted otherwise on drawings.
2. Bury ground ring not less than 24 inches from building foundation.

K. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor sized the same as building grounding electrode conductor and shall not be smaller than 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Locate at or near bottom of footing with minimum 2 inches concrete encasement.
3. 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.

3.4 TERMINATIONS AND CONNECTIONS

A. Make terminations and connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Test Wells: Use exothermic welded connections.

F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. Manufacturer's Field Service – Electrolytic Grounding System: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

G. Excessive Ground Resistance: If resistance to ground exceeds specified values above, provide additional grounding electrodes to meet values above.

H. Provide a grounding system test in accordance with NFPA-99 for all patient care areas. Include test results in close-out documents. A Hampden Ground Integrity Tester Model MVO-1-PB or equivalent shall be used for grounding system test.

END OF SECTION 26 05 26

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SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported conduit systems and their contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit. Consider weight of wire in conduit when selecting products. For empty conduits, include weight of 5 type XHHW wires of maximum permissible size.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components.
4. Equipment supports.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Cooper B-Line, Inc.; a division of Cooper Industries.
    b. ERICO International Corporation.
    c. Thomas & Betts Corporation.
    d. Unistrut; Tyco International, Ltd.
    e. Hilti Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.
4. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
5. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
6. Rated Strength: Selected to suit applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. 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.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron in non- corrosive areas and fiberglass or stainless steel in corrosive areas.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized in non-corrosive areas and Stainless Steel (in corrosive areas).

F. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. Fabco Plastics Wholesale Limited.
    d. Seasafe, Inc.

2. Channel Dimensions: Selected for applicable load criteria.

3. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
4. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
5. Rated Strength: Selected to suit applicable load criteria.

G. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

H. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Power-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used. Approval from structural engineer shall be obtained prior to the use of power-actuated fasteners.

    a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Hilti Inc.
        2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

    a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Galvanized 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 Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter and except where support spacing requirements exceed NFPA 70 requirements.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted 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 for conduits 1 ¼ inch and larger, single-bolt conduit clamps for conduits 1 inch and smaller and as approved by an agency acceptable to the authority having jurisdiction.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts; Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

E. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.

F. Obtain permission from Structural Engineer before drilling or cutting structural members.

G. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.

H. Install surface mounted cabinets and panelboards with minimum of four anchors.

I. In wet and damp locations use steel channel supports to stand cabinets and panelboards one inch off wall.

3.3 LIGHTING FIXTURES

A. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

B. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers and swivel aligners.
3. Verify stem/pendant/rod length.
4. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

C. Install channel supports across main grid runners or grid supports, securely tied down or anchored for fixtures and devices mounted in suspended ceiling systems so as not to cause tile to sag and so that fixture or device cannot be lifted, rotated, or displaced.

3.4 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.5 PAINTING

A. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

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SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures, and cabinets.

B. Related Requirements:

1. Division 7 for firestopping at conduit and box entrances.

1.3 ACTION SUBMITTALS

A. Product Data: For wireways and fittings, hinged-cover enclosures, and cabinets.

B. Sustainable Design Submittals:

1. Product Data: For solvents and adhesives, indicating VOC content.

1.4 COORDINATION

A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; a part of Atkore International.
b. Electri-Flex Company.
c. Republic Conduit.
d. Thomas & Betts Corporation; A Member of the ABB Group.
e. Western Tube and Conduit Corporation.
f. Wheatland Tube Company.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. RMC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203.
5. Fittings for EMT:

    a. Material: Steel.
    b. Type: Setscrew.

6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651for PVC and type XJ for steel, rated for environmental conditions where installed, and including flexible external bonding jumper.

C. Joint Compound for IMC, GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit; a part of Atkore International.
    b. CANTEX, Inc.
    c. Electri-Flex Company.
    d. Kraloy
    e. Lamson & Sessions; Carlong Electrical Products.
    f. Thomas & Betts Corporation; A Member of the ABB Group.

2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
3. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:

1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
3. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.
5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, as require for installation location and sized according to NFPA 70.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: ANSI 61 Gray for steel wireways.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Crouse-Hinds, an Eaton business.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. FSR Inc.
5. Hoffman; a brand of Pentair Equipment Protection.
6. Hubbell Incorporated.
7. Kraloy.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. RACO; Hubbell.
10. Thomas & Betts Corporation; A Member of the ABB Group.
11. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, deep-type, ferrous alloy, Type FD, with gasketed cover, threaded hubs.

E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb. shall be listed and marked for the maximum allowable weight.

F. Sheet Metal Pull and Junction Boxes: NEMA OS 1, galvanized steel.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover and stainless-steel cover screws.

1. Flanged Type boxes shall be used where installed flush in wall.

H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

J. Telecommunications and Security Device Box Dimensions: 4 11/16 inches square by 2-1/8 inches deep unless noted otherwise.

K. Gangable boxes are prohibited.

L. Accessories

1. Fire rated Moldable pads: UL #9700, moldable sheet putty at required thickness on all five sides of back boxes. Acceptable manufacturers: Kinetics Noise Control, IsoBacker Pad, SSP Putty and Pads or equal.
2. Sound Barrier Insulation Pads: Mastic, non-harding, sheet material, and minimum 1/8" thickness applied to all five sides of the back boxes. Acceptable manufacturers: Kinetics Noise Control, SealTight Backer Pad and L.H. Dottie Co., #68 or equal.

PART 3 - EXECUTION

3.1 RACEWAY SIZING

A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to NEC. (Latest Edition). Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the National Electrical Code (to include enlarged conductor's due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

B. Minimum (Unless noted otherwise) Raceway Size 1/2-inch (16-mm) trade size.

C. Minimum Raceway Size Telecommunication and Security Conduit: 1 inch, unless noted otherwise in documents.

D. Minimum Raceway Size Control Conduit: 1/2-inch, unless noted otherwise in documents.

E. Minimum Raceway Size; Below Grade 5'-0" or less from Building Foundation: 1 inch, unless noted otherwise in documents.

F. Minimum Raceway Size; Below Grade more than 5'-0" from Building Foundation: 1-inch, unless noted otherwise in documents.

G. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: RMC, IMC.
2. Concealed Conduit, Aboveground: RMC, IMC.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Physical Damage: RMC for first 8'-0" above fixed floor, than EMT. Raceway locations include the following:

a. Parts Room.
b. Lube/Compressor Room.
c. Light Duty Maintenance Bays.
d. Wash Bay
e. Heavy Vehicle Repair Bays
f. Chassis Wash
g. Welding Bay
h. Body Shop
i. Install Bays
j. Service Bays
k. Parts Storage

4. In or under slabs on grade (only to serve floor boxes): RNC, Type EPC-40-PVC**.**
5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
7. Flexible Metal Conduit (FMC) ¾ inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire. Flexible metal conduit may be a manufactured, UL listed 3/8-inch flexible metal conduit and fittings with #14 AWG THHN conductors and an insulated ground wire. Maximum length of 3/8 inch FMC shall be six (6) feet.
8. Damp or Wet Locations: RMC, IMC.
9. Damp or Wet Locations and subject to Physical Damage: RMC
10. Hazardous Locations: All raceways installed in hazardous locations shall be suitable for locations as defined in the NEC Article 500.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. Rigid Nonmetallic Conduit: Use PVC fittings, unless otherwise indicated.
3. EMT: Use setscrew, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

3.3 BOXES AND ENCLOSURES APPLICATIONS

A. Boxes and Enclosures:

1. NEMA 250, Type 1, except use NEMA 250, Type 3R in damp or wet locations.
2. Dirty locations: NEMA 250, Type 12.
3. Hazardous Locations: All boxes and enclosures installed in hazardous locations shall be suitable for locations as defined by NEC Article 500.

3.4 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. In general, conduits shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

D. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, rough through jack with pitch pocket. Coordinate roof penetrations with others.

E. Conduit runs shall be routed as shown on the large-scale drawings. Conduit routing on drawings scaled ¼" =1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Contractor based on information provided in the contract documents, in accordance with manufacturer's written instructions, applicable coded, NECA 1 and NECA 101 and coordinated with other contractors.

F. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

G. Do not fasten conduits onto the bottom side of a metal deck roof.

H. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

I. Complete raceway installation before starting conductor installation.

J. Install temporary closures to prevent foreign matter from entering raceways.

K. Unused openings in boxes and fittings shall be plugged with suitable devices rated for the proper environment.

L. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.

M. Arrange stub-ups so curved portions of bends are not visible above finished slab. Where rigid non-metallic conduit (RNC) conduit is used below grade, in slab, below slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits the earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.

N. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

O. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction and within 12 inches of enclosures to which attached to.

P. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

Q. Conceal conduit within finished walls and ceilings unless otherwise indicated. Install conduits parallel or perpendicular to building lines. Conduit runs installed above suspended ceilings shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit supports.

R. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.

1. Run parallel or banked raceways together on common supports.
2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

S. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

T. Telecommunication Conduits:

1. Conduits that protrude through the structural floor shall be installed 1 to 3” above finished floor (AFF).
2. Conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4-inches below ceiling and as close to the wall as possible
3. Conduits that are below grade and enter the building shall terminate a minimum of 4-inches above finished floor (AFF) and as close to the wall as possible.
4. Condit terminations shall have nylon bushings installed on each end of every conduit run.
5. Telecommunication conduits shall have no more than two (2) 90 degree bends between pull points and contain no continuous sections longer than 100 feet. Insert pull points or pull boxes for conduits exceeding 100 feet in length. A third bend is acceptable if: The total run is no longer than (33) feet.
6. The conduit size is increased to the next trade size.
7. Telecommunications pull boxes shall not be used in lieu of a bend. Align conduits that enter into the pull box from the opposite ends with each other. Pull box size shall be twelve (12) times the diameter of the largest conduit. Slip sleeves or gutters can be used in place of a pull box.
8. Conduit bend radius shall be six (6) times the diameter for conduits under 2-inches and ten (10) times the diameter for conduits over 2-inches.

U. Contractor shall be responsible for all openings required in masonry or exterior walls under this division. A qualified mason at the expense of this contractor shall repair all openings to match existing conditions.

3.5 CONDUIT TERMINATIONS

A. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

B. Join raceways with fittings designed and approved for that purpose and make joints tight.

C. When raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.

D. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

E. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

F. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

G. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

H. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

J. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

K. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

L. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

M. Expansion fittings shall be installed across expansion joints in structures and concrete construction where such joints are shown on the architectural and structural drawings.

N. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

O. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

3.6 BOX INSTALLATION

A. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

B. Recessed Boxes in Masonry Walls: Saw-cut opening for box in corner of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

C. Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and provide 18 inch by 24 inch access doors.

D. No back to back outlet boxes shall be installed.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer’s instructions.
2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated stud walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches of the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads on all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

E. Electrical box locations shown on drawings are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

F. No outlet shall be located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.

G. It shall be the Contractor's responsibility to study drawings pertaining to other trades, to discuss location of outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.

H. The proper location of each outlet is considered a part of this contract and no additional compensation will be paid to the Contractor for moving outlets which were improperly located.

I. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

J. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

K. Locate boxes so that cover or plate will not span different building finishes.

L. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

M. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

N. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 7.

3.9 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 26 05 33

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SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including RMC.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Polymer concrete handholes and boxes with polymer concrete cover.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including spacers and miscellaneous components.
2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for handholes.
4. Include underground-line warning tape.

B. Shop Drawings:
1. Factory-Fabricated Handholes:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. RMC: Comply with ANSI C80.1 and UL 6.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Tube & Conduit; a part of Atkore International.
2. Republic Conduit.
3. Thomas & Betts Corporation; A Member of the ABB Group.
4. Western Tube and Conduit Corporation.
5. Wheatland Tube Company.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Tube and Conduit; a part of Atkore International.
2. CANTEX INC.
3. Kraloy.
4. Lamson & Sessions; Carlong Electrical Products.
5. Thomas & Betts Corporation; A Member of the ABB GRoup.

2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.4 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armorcast Products Company.
2. Oldcastle Enclosure Solutions.
3. Quazite: Hubbell Power Systems, Inc.

C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

D. Color: Gray.

E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, as indicated for each service.

I. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into handholes and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

B. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
2. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 15 structural load rating.
3. Units Subject to Light-Duty Pedestrian Traffic Only: Polymer concrete units, SCTE 77, Tier 8.
4. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 but do not use heavy-duty, hydraulic-operated, compaction equipment.

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Building Wall Penetrations: Make a transition from underground duct to RMC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings

manufactured for RNC-to-RMC transition. Install RMC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

G. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

H. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.

I. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 3 inches wider than duct on each side.
3. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
4. Set elevation of bottom of duct bank below frost line.
5. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
8. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

    a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.

J. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF HANDHOLES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below frost line.

E. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.7 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch- long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 26 05 43

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SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

C. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

D. Pressure Plates: Carbon steel.

E. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

B. 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. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.

2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they 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, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 05 44

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SECTION 26 05 72

OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

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 a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.

2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

3. Submit study report for action prior to receiving final approval of the 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 the selection of devices and associated characteristics is satisfactory.

4. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Software Developer.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Easy Power.
2. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall 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.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
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 the 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: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:

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.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Calculated asymmetrical fault currents:

        1) Based on fault-point X/R ratio.
        2) Based on calculated symmetrical value multiplied by 1.6.
        3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    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 a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
6. Motor horsepower and NEMA MG 1 code letter designation.
7. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Low-voltage switchgear.
3. Control panels.

4. Branch circuit panelboards.
5. Disconnect switches.

3.3 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 26 05 72

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SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

1.3 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the 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 the selection of devices and associated characteristics is satisfactory.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. The following parts from the Protective Device Coordination Study Report:

        1) One-line diagram.
        2) Protective device coordination study.
        3) Time-current coordination curves.

    b. Power system data.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Comply with IEEE 242 and IEEE 399.

B. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

    a. Arcing faults.
    b. Simultaneous faults.
    c. Explicit negative sequence.
    d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Switchboard and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.
        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

G. 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 the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the 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. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    c. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    d. Cables and conductors damage curves.
    e. Ground-fault protective devices.
    f. Motor-starting characteristics and motor damage points.
    g. The largest feeder circuit breaker in each panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. 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. 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 PROTECTIVE DEVICE 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. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall 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 shall 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 the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Low-voltage switchboard.
3. Branch circuit panelboards.

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of electrical equipment bus bars to withstand short-circuit stresses.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.4 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Short-circuit current at each system bus, three phase and line-to-ground.

4. Full-load current of all loads.
5. Voltage level at each bus.
6. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
7. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
8. Maximum demands from service meters.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
11. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

3.5 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the 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 73

SECTION 26 05 74

OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

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 a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
3. Submit study report for action prior to receiving final approval of the 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 the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Software Developer.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Easy Power.
2. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.

4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    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 a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

G. 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. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall 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:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the 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 all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.

2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 LABELING

A. Apply one arc-flash label for 480-V ac and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Low-voltage switchboard.
2. Control panel.

3.5 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION 26 05 74

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SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes commissioning process requirements for Lighting systems and Electrical Metering.

B. Related Sections:

1. Division 01 Section "Commissioning" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. Attend construction phase controls coordination meeting.

B. Perform commissioning tests at the direction of the CxA.

C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

D. Provide information requested by the CxA for final commissioning documentation.

1.5 CxA'S RESPONSIBILITIES

A. Review equipment and control systems submittals.

B. Provide Project-specific construction checklists and commissioning process test procedures for actual systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

C. Direct commissioning testing.

D. Provide Systems Manual.

1.6 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists, setting controls and starting operation as specified for Lighting systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, and startup procedures have been completed.
5. Test and inspection reports and certificates.
6. Corrective action documents.

1.7 SUBMITTALS

A. Certificates of completion of installation and control settings.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that Electrical systems, subsystems, and equipment have been installed, calibrated and started and are operating according to the Contract Documents.

3.2 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of testing shall include lighting controls and electrical metering. Testing shall include measuring effectiveness of operational and control functions.

C. The CxA along with the Electrical Subcontractor shall prepare detailed testing plans, procedures, and checklists for Lighting systems, subsystems, and equipment.

D. The following equipment and systems will be tested.

1. Occupancy Lighting Controls
2. Photocell Controllers
3. Electrical Metering

END OF SECTION 26 08 00

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Indoor occupancy sensors.

B. Related Requirements:

1. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SYSTEM DESCRIPTION

A. Occupancy Sensors

1. Occupancy sensors shown on drawings are intended to show control intent. Quantities and locations are approximate and may not include all devices required for 100% coverage to meet energy code requirements. It shall be the contractor's responsibility to provide a complete Occupancy Sensor system based on the performance requirements of this specification and energy code requirements.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show installation details for occupancy sensors.

1. Floor plans indicating exact quantity and locations of devices for 100% sensor coverage based on manufacturer's requirements.
2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Sensor Switch as indicated on drawings or comparable product by one of the following:

1. Leviton Mfg. Company Inc.
2. Watt Stopper

B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operation: 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.
3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
5. Mounting:
    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
7. Bypass Switch: Override the "on" function in case of sensor failure.
8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. PIR Type: Ceiling mounted; detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..

D. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

E. Dual-Technology Type: 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. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

2.2 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Sensor Switch as specified on drawings or comparable product by one of the following:

1. Leviton Mfg. Company Inc.
2. Watt Stopper

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Switch Rating: Not less than 800-VA at 120 V, 1200-VA at 277 V.

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: Passive Infrared.
3. Switch Type: SP and dual circuit, field selectable automatic "on," or manual "on" automatic "off."
4. Voltage: Dual voltage, 120 and 277 V.
5. 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.
6. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.

2.3 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "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 Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

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 written instructions.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. 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.

C. Lighting control devices will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 3 months from date of Substantial Completion, provide on-site assistance in adjusting sensors 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.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 26 09 23

SECTION 26 09 43

SIGNAL VOLTAGE LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes manually operated lighting controls with relays and control module.

B. Section includes manually operated, PC-based, digital lighting controls with external signal source relays and control module.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, manual switches and plates, and conductors and cables.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
3. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.

1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
3. Field quality-control reports.
4. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
5. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of lighting control functions.

B. Coordinate lighting control components specified in this Section with components specified in Section 262416 "Panelboards."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.

2. Failures include, but are not limited to, the following:

a. Failure of software input/output to execute switching or dimming commands.
b. Failure of modular relays to operate under manual or software commands.
c. Damage of electronic components due to transient voltage surges.

3. Warranty Period: Two years from date of Substantial Completion.
4. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.
5. Extended Warranty Period for Electrically Held Relays: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Electronic Theater Controls (ETC), Inc.
2. Lutron
3. Watt Stopper/Legrand

2.2 SYSTEM REQUIREMENTS

A. Relay Panel:

1. Shall be Factory Assembled and UL Listed and house all components as required.
2. Cover shall accommodate surface mounting or flush mounted as indicated on the drawings
3. Panel shall have dead front barrier separation for line voltage compartment.
4. Panels shall include appropriate barrier strips for mounting relays and for separating low voltage wiring from line voltage wiring.
5. Allow empty enclosures to be shipped prior to interiors for electrical rough in.
6. This contractor shall connect low voltage wires and signal voltage control wires to applicable terminal blocks in cabinets.

B. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.

C. Performance Requirements: Manual switch operation sends a signal to network-system control module that processes the signal according to its programming and routes an open or close command to one or more relays in the power-supply circuits to groups of lighting fixtures or other loads.

D. Low voltage control panels shall be microprocessor based with touch screen display or handheld pluggable display interface.

E. Programmable options shall include time-of-day control, 32 holiday dates, warning signal for impending swipe-off time, preset controls, astronomical clock, daylight sensor, photocell control, digital switches inputs and network override interface from Building Automation System via Modbus, N2 or BACnet interface depend on the BAS selected.

F. The lighting controls system may also be fully programmed from the remote PC with programmable software.

2.3 CONTROL MODULE

A. Control Module Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral alphanumeric LCD or LED shall display menu-assisted programming and control.

1. Multichannel output with number of channels shown on drawings.
2. Multiple inputs for occupancy sensors and multichannel outputs.

B. RELAYS

1. Relays shall be split coil, mechanically latching design, 24 volts AC or DC, electrically operated with load contacts rated at 20 amps, 120/277 volts, UL and CSA listed.
2. Single or Double pole 20 A relay shall provide:

    a. ON/OFF control of lighting.
    b. 0-10 volt dimming control
    c. Full life and voltage rating up to 277 VAC
    d. 1,500 Amp in-rush capability.
    e. 5,000 Amp “no damage” short circuit rating

2.4 POWER DISTRIBUTION COMPONENTS

A. Modular Relay Panel: Comply with UL 508 (CAN/CSA C22.2, No. 14), UL 916 (CSA C22.2, No. 205), and UL 924; factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.

1. Cabinet: Steel with hinged, locking door.

a. Barriers separate low-voltage and line-voltage components.
b. Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.
c. Control Power Supply: Transformer and full-wave rectifier with filtered dc output.
d. Barriers to separate normal lighting circuit from emergency lighting circuits where indicated on the drawings

2. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.

a. Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.
b. Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.
c. Endurance: 50,000 cycles at rated capacity.
d. Mounting: Provision for easy removal and installation in relay cabinet.

B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels or field-mounting surge suppressors that comply with Section 264313 "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for Category A locations.

2.5 FIELD-MOUNTED DIGITAL CONTROLS AND PLATES

A. Connection Type: RS-485 protocol, category 6 UTP cable, using RJ45 connectors. Power shall be from the control unit.

B. Pushbutton Switches: Modular, solid-state, programmable, digital, momentary contact, designed to connect to a microprocessor based control unit as a manual control source.

1. Mounting: Standard single-gang recessed switchbox, using device plates specified in Section 262726 "Wiring Devices."
2. Multi-Gang Mounting: One to six pushbuttons per gang.
3. Switches shall be provided with lighted LED indicators to identify when relays/switches are in “ON” or “OFF” position

2.6 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cables: Stranded copper, complying with UL 83, multi-conductor cable with copper conductors not smaller than No. 22 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Stranded copper, complying with UL 83, multi-conductor cable with copper conductors not smaller than No. 16 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

2.7 DIGITAL TIME CLOCK

A. Digital Time Clock (DTC) shall control and program the entire lighting control system and supply all time functions and accept interface inputs.

B. DTC shall be capable of up to 32 schedules. Each schedule shall consist of one set of On and Off times per day for each day of the week and for each of two holiday lists. The schedules shall apply to any individual relay or group of relays.

C. The DTC shall be run from non-volatile memory so that all system programming and real time clock functions are maintained for a minimum of 15 years with loss of power.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install wiring in raceways. Comply with Division 26. Minimum conduit size shall be 3/4 inch.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

D. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.

E. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated. Install in accordance with manufacturer's instructions.

F. The Electrical Contractor shall be accountable for installing the Class 2 low voltage control wire for the lighting control system in accordance with the factory recommendations and shop drawings.

G. All Class 2 low voltage control wire shall be installed in conduit and labeled on both ends to match the designations on the submittal drawings.

H. Tag all wires and provide typewritten directories on inside cover identifying relays and associated circuit and room or area designation.

I. Demonstrate proper operation of system. The manufacturer’s representative shall be responsible for coordinating the system installation with the Electrical Contractor; they shall also be liable for any return visits by the factory engineer as a result of incomplete or incorrect wiring.

J. The manufacturer shall meet with the owner’s representative prior to system commissioning to provide basic system programming, which will be installed at commissioning.

K. Upon completion of the formal checkout, the factory engineer shall demonstrate operation and maintenance of the system to the owner’s representatives. Training shall not exceed eight hours on the job site.

L. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.

M. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Test for circuit continuity.
2. Verify that the control module features are operational.
3. Check operation of local override controls.

D. Lighting controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.3 SOFTWARE INSTALLATION

A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls.

3.6 WARRANTY

A. Electrical Contractor shall provide two years warranty from the date of building substantial completion or manufacturer’s standard warranty, whichever is longer on all equipment and installation provided. Warranty shall cover a 100% of the cost of repair or replace any parts required over the first two years which are directly attributable to the manufacturer/EC.

END OF SECTION 26 09 43

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, vibration isolation devices, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control test reports.

B. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

D. Test and inspect transformers according to IEEE C57.12.91.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.8 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum or copper.

D. Nominal System Voltages:

1. Primary voltage 480V 3 phase, delta connected, unless noted otherwise.
2. Secondary voltage 208/120 volts, 3 phase, wye connected, unless noted otherwise.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250, Type 2 for indoor transformers.
1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

Finish Color: Gray.

E. Transformer Taps:

1. Taps for Transformers Smaller Than 3 kVA: None.

2. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.
3. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

G. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.
3. Label in accordance with NEMA TP 3 requirements.

H. Wall Brackets: Manufacturer's standard brackets. Provide for wall mounted transformers indicated on drawings.

I. Low Sound-Level Requirements: Shall not exceed NEMA ST20 standard sound levels when factory tested according to IEEE C57.12.91.

1. 15 to 29kVA: 40 dba.
2. 30 to 50 kVA: 45 dBA.
3. 51 to 150 kVA: 50 dBA.
4. 151 to 300 kVA: 55 dBA.
5. 301 to 500 kVA: 60 dBA.
6. 501 to 750 kVA: 62 dBA.
7. 751 to 1000 kVA: 64 dBA.

2.4 VIBRATION ISOLATION DEVICES

A. Manufacturer: Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries products specified herein or a comparable product by one of the following:

1. Mason Industries
2. Korfund Company
3. Amber-Booth Company
4. Consolidated Kinetics Corporation
5. M.W. Sausse.

B. All isolation devices shall be designed for the equipment with which they will be used. Materials used shall retain their isolation characteristics for the life of the equipment served. All elastomeric materials shall be industrial grade neoprene. Isolation devices subject to weather shall have hot dipped galvanized finish.

C. Type 2 Mounts: Type W or K neoprene pads. Both surfaces shall be rib molded for skid resistance. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above the mountings to compensate for the overhang.

D. Type 5 Hangers: Mason type 30N, vibration hangers with a steel spring and 0.3" deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degrees arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

2.5 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION ISOLATION APPLICATION

A. Use type 2 mounts for transformers installed on concrete slabs or mezzanine floors and where supports and attachments do not have to meet seismic forces defined in ASCE 7-05.

B. Use type 5 hangers for suspended transformers where supports and attachments do not have to meet seismic forces defined in ASCE 7-05.

3.3 INSTALLATION

A. Equipment Mounting: Install transformers on concrete bases complying with Division 26 Section "Common Work Results for Electrical."

B. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

C. Set transformers plumb and level.

D. Install vibration isolation devices according to Manufacturer’s written instructions.

E. Suspended transformers shall be coordinated with structure with hangers sized to handle transformer physical weight.

F. Maintain a minimum distance of 6 inches from transformer enclosure to adjacent surfaces and equipment.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform visual and mechanical inspection and electrical tests. Test procedures and values shall be in accordance with NETA-2007 requirements. Certify compliance with test parameters.
2. Compare equipment nameplate data with drawings and specifications.
3. Inspect physical and mechanical condition, anchorage, alignment, and grounding
4. Verify that resilient mounts are free and that any shipping brackets have been removed.

5. Verify the unit is clean.
6. Inspect bolted electrical connections for high resistance

    a. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA-2007, Table 100.12.
    b. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

7. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data or in the absence of manufacturer's published data, use NETA-2007, Table 100.5.
8. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

D. Any transformers deemed to be noisy by Engineer shall have actual dB level of transformer verified by manufacturer. Any transformer exceeding NEMA standard sound levels shall be replaced.

3.6 ADJUSTING

A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit voltage readings and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.7 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00

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SECTION 26 24 13

SWITCHBOARDS

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. Service and distribution switchboards rated 600 V and less.
2. Disconnecting and overcurrent protective devices.
3. Instrumentation.
4. Control power.
5. Accessory components and features.
6. Identification.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, ground-fault protector, accessory, and component indicated. 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, conduit entrances, 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 NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices indicating that the devices are fully rated (series rated devices are not allowed)
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of listing for fully rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATION SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

C. Routine maintenance requirements for switchboards and all installed components.
Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

D. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Lift using manufacturer supplied attachments.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.8 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

1.9 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. 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.

C. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide switchboards comparable to Square D QED Style Switchboards or comparable product by one of the following manufacturers. The listing of a manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. Square D; a brand of Schneider Electric.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: as indicated on the drawings.

D. Main-Bus Continuous: Ampacities and short circuit ratings as indicated on the drawings.

E. Each switchboard, as a complete unit, including service circuit breaker, shall be given a single withstand circuit rating by the manufacturer. The withstand short circuit rating shall certify that all equipment is capable of withstanding the stress of a fault equal to the interrupting rating of the least overcurrent protective device contained herein. Such rating shall be established by actual tests by the manufacturer on equipment constructed similarly to the subject switchboard. The test data shall be available and shall be furnished to the engineer. The short circuit current rating of 50 KA RMS symmetrical amperes, minimum, unless otherwise noted on drawings. Busing shall be copper.

F. Indoor Enclosures: Steel, NEMA 250, Type 1.

1. The switchboard framework shall consist of steel channels welded or bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting. The framework is to be formed, code gauge steel, rigidly welded and bolted together to support all coverplates, bussing, and component devices during shipping and installation.
2. Each switchboard section shall have an individual removable plate for installation and termination of conduit. The wireway front covers are to be hinged to permit access to the load side terminals without removing the covers. All front plates used for mounting meters, selector switches, or other front mounted devices shall be hinged with all wiring installed and laced with flexibility on the hinged side. All closure plates shall be screw removable. The paint finish shall be gray enamel over a rust-inhibiting phosphate primer.
3. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

G. Barriers: Between adjacent switchboard sections.

H. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps are required by utility company. If separate vertical section is required for

utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

I. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

J. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

K. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity. The bussing shall be of sufficient cross sectional area to continuously conduct rated full load current and meet UL Standard 891 temperature rise requirements.
2. Ground Bus: Minimum-size required by UL 891**,** hard-drawn copper of 98 percent conductivity, equipped with mechanical type connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
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. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical type connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
5. The bus bars shall be rigidly braced to comply with the integrated rating of the switchboard.
6. The main horizontal bus bars between sections shall be located at the back of the switchboard to permit a maximum of available conduit area. The horizontal bus bar supports, connections and joints are to be bolted with grade 5 carriage bolts and Belleville washers to minimize maintenance requirements.

L. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Where required to achieve system coordination with upstream and downstream overcurrent devices, solid-state, electronic trip, circuit breakers shall be provided and where noted on drawings and schedules.
2. 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.
3. Solid State, electronic trip circuit breakers 100% rated, full function, with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response. Ground fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Provide ground fault only where indicated on drawings.
    e. Overload and short-circuit and ground-fault trip indicators shall be provided.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large permanent, individual circuit numbers shall be affixed to each breaker in a uniform position (or equip each breaker with a circuit card holder and neatly printed card identifying the circuit). Tripped indication shall be clearly shown by the breaker handle taking a position between ON and OFF. A trip button shall be provided for mechanically tripping the circuit breaker. This allows maintenance checks on the breaker, control circuits, alarm devices, and other associated equipment.
c. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material
d. Provide the following where noted on the drawings or schedules:

1) Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
2) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
3) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
4) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
5) Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
6) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.3 INSTRUMENTATION

A. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

B. Shall be Square D Power Logic PM5500 Series with digital display and the following features.

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Megawatts: Plus or minus 2 percent.
e. Megavars: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.

2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

3. Communication Support: BACnet IP communications over Ethernet.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

B. Provisions for future breakers. Provisions for future breakers shall be such that no additional connectors will be required to add breakers.

2.5 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

E. Verify service details with the utility prior to submitting bid.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1, in accordance with manufacturer's written instructions, and in accordance with recognized industry practices.

B. Equipment Mounting: Install switchboards on concrete bases complying with Division 26 Section "Common Work Results for Electrical."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the 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.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, and instrumentation.

G. Set field-adjustable switches and circuit-breaker trip ranges in accordance with coordination study.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. All conductors and bus connections shall be torqued to manufacturer's connections.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

B. Test insulation resistance for each switchboard bus section, (phase-to-phase and phase-to-ground), component, connecting supply, feeder, and control circuit in accordance with latest version of the NETA Acceptance Testing Specification Chapter 7.

C. Test continuity of each circuit.

D. Perform field test prior to energization

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
4. Switchboard will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTMENT AND CLEANING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer. Ensure free mechanical movement may occur.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "System Studies."

C. Tighten Bus connections and mechanical fasteners.

D. Touch-up paint shall be applied to scratched or marred surfaces to match original finish.

E. Clean interior of switchboard of all dirt and debris.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 26 24 13

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SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Coordinate Branch Panelboards
4. Disconnecting and Overcurrent Protective Devices

1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective devices, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Submit required short circuit coordination study per specification section 26 05 73 to the consulting engineer for review and approval. Submittal shall be on or before date of panelboard equipment submittal.

C. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and electrical ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. Field quality control test results
8. Operating and Maintenance data.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
3. Copies of all panelboard typewritten directories.

B. Record Drawings: Create and submit record drawings including the final version of each panel schedule after load balancing. Create drawings matching the record set and incorporate final panel schedules on drawing and add panel schedule sheets to drawing index.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with National Electrical Manufacturer's Association (NEMA) Standards Publication Number PB1.1 and PB 1.2.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards.

B. Do not store panelboards exposed to weather.

C. Handle and prepare panelboards for installation according to NEMA PB 1.

D. Protect panelboards against damage from work of other trades.

1.7 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Keys: Two spares for each type of panelboard cabinet lock.

C. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: spares for each panelboard as shown on one the Panel Schedules.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials; design and construction in accordance with published product information; equip with proper number of unit panelboard devices as required for complete installation. Where types, sizes or ratings are not indicated, comply with NEC, UL and established industry standards for those applications indicated. Provide circuit directory in clear plastic cover. Provide panelboards with lugs suit-

able for termination of feeder sizes indicated on drawings.

B. Each panelboard, as complete unit, shall have a short circuit current rating equal to or great than the integrated equipment rating shown on the panelboard schedule or on the plans. This rating shall be established by testing with the overcurrent devices mounted in the panelboard. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage. All panelboards shall be fully rated, series rated panels are not approved.

C. Enclosures: Flush and surface mounted cabinets. Refer to panel schedule and floor plans for types of panel cabinets required.

1. Rated for environmental conditions at installed location.

    a. Indoor Dry and Clean Locations: NEMA 250, type 1.
    b. Other Wet or Damp Indoor Locations: NEMA 250, type 4.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Provide full height hinged trim integrated into front cover to allow access to wire gutters without the removal of cover. Provide hinged door for access to overcurrent devices.
3. Back Boxes: Galvanized steel.
4. Directory Card: Inside panelboard door, mounted in transparent card holder.
5. Incoming Mains Location: Top or bottom. Mains location is at the contactor's option as project conditions dictate, unless specifically indicated otherwise on the drawings.
6. Phase, Neutral, and Ground Buses:

    a. Material: Hard-drawn copper, 98 percent conductivity.
    b. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type. Lugs shall be of sizes as required to accept feeders as indicated on the drawings.
4. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rated panels are not approved.

2.2 DISTRIBUTION PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D I-Line type distribution panelboards or comparable product by one of the following. The listing of a manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. Square D; a brand of Schneider Electric.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, power and feeder 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 main lugs only as indicated on the Panel Schedules.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers or plug-in circuit breakers, where individual positive-locking device requires mechanical release for removal.

G. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs. Provide on panels where specifically noted on the panel schedules or one line diagram.
2. Copper equipment and isolated ground buses. Provide on panels where specifically noted on the panel schedules or one line diagram.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D NQOD series panelboards or comparable product by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. Square D; a brand of Schneider Electric.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or main lugs only as indicated on the on the Panel Schedules.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs. Provide on panels where specifically noted on the panel schedules or one line diagram.
2. Copper equipment and isolated ground buses. Provide on panels where specifically noted on the panel schedules or one line diagram.

F. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

G. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

H. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.4 COORDINATION BRANCH PANELBOARDS

A. Branch Circuit Panelboards: Fusible switch type with current limiting Class J time delay or equivalent protection

B. The panelboard and overcurrent devices contained within shall be fully rated.

C. Enclosure: Type 1. Minimum cabinet size: 5-3/4 inches (144 mm) deep; 20 inches (508 mm) wide with 5" minimum gutter space top and bottom. Constructed of galvanized code gauge steel. Panel enclosure (back box) shall be of non-stamped type (without KO's) to avoid concentric break out problem.

D. Provide surface cabinet front with concealed trim clamps, concealed hinge and flush cylinder lock all keyed alike. Front cover shall be hinged to allow access to wiring gutters without removal of panel trim. Hinged trim shall be held in place with screw fasteners. Finish in manufacturer's standard gray enamel.

E. Provide metal directory holders with clear plastic covers. Holder to be factory mounted.

F. Provide panelboards with copper bus (phase buses, bus fingers, etc.), ratings as scheduled on Drawings. Provide ground bars in all panelboards. Phase, neutral and ground bar terminations can be dual rated ALCU9. All spaces shall have bus fully extended and drilled for the future installation of devices.

G. Surge Protective Device: Provide a surge protective device meeting the requirements of specification section 26 43 13.

H. Overcurrent devices shall be fused branch disconnects including compact base and fuse holder with the following features:

1. Current limiting Class J time delay or equivalent protection.
2. Single handle common trip, 1-, 2-, and 3 pole versions.
3. Bolt on type
4. Local open fuse indication
5. UL listed for type and temperature rating of wire specified.
6. Permanently installed integrated lockout / tag out provisions.
7. 600V AC rated.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; a brand of Schneider Electric.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

C. Where required to achieve system coordination with upstream and downstream overcurrent devices, solid-state, electronic trip, circuit breakers shall be provided and where noted on drawings and schedules.

D. 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.

E. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

F. Solid State, electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

G. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

H. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

J. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor materials.
3. Provide the following where noted on the drawings or schedules:

    a. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    b. Handle Clamp: Loose attachment, for holding circuit breaker handle in the on position.
    c. Lockable: Fixed attachment for padlocking circuit breaker handle in the on or off position.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to manufacturer's written instructions, according to NEMA PB 1.1, and in accordance with recognized industry standards.

B. Mount panelboards recessed within a wall or surface mounted as indicated on drawings and schedules.

C. Support panel cabinets independently to structure with no weight bearing on conduits.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

E. Mount so that top breaker is not higher than 6'-0" AFF, unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush and tight with wall finish and mating with back box.

G. Adjacent panel cabinets shall be of same physical size and mounted in horizontal alignment.

H. Provide lugs in panelboards of adequate size to accept feeders as indicated on drawings.

I. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

2. Install filler plates in unused spaces.
3. Provide handle clamp accessory for any circuit breaker serving fire alarm control panels or fire alarm power supplies.
4. Provide lockable handle padlock circuit breaker attachment where noted on panel schedules or plans as lockable option.

J. Provide one ¾" empty conduit for each three panel spaces between panelboard and accessible ceiling space or space designated to be ceiling space in the future, for future use. On recessed mounted panel boards, stub four 2-inch empty conduits**.**

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable. Verify actual room names and numbers to be used, and include room name, room number and name of load being served for every circuit.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
2. Megger check and test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit. Do not megger check solid state components.
3. Test continuity of each circuit.
4. Energize each circuit and check for complete function.
5. Set adjustable trip circuit breakers in accordance with coordination study.

B. Panelboards will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Touch up paint scratched or marred surfaces to match original finish.

3.5 ADJUSTING AND CLEANING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 10 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

C. Tighten lugs and bus connections.

D. Clean interior of panelboard.

END OF SECTION 26 24 16

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. Hazardous (classified) location receptacles.
4. Twist-locking receptacles.
5. Toggle switches, 120/277 V, 20 A.
6. Digital timer light switches.
7. Wall-box dimmers.
8. Wall plates.
9. Floor Boxes.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

F. Device Color:

1. Wiring Devices: White unless otherwise indicated or required by NFPA 70 or device listing.

G. Wall Plate Color: For plastic covers, match device color.

H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Duplex Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.

C. Weather-Resistant Duplex Receptacle, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 GFCI RECEPTACLES, 125 V, 20 A

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Duplex GFCI Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: Non-feed through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

C. Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Type: Non-feed through.
4. Standards: Comply with UL 498 and UL 943 Class A.
5. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" articles.

2.4 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Hazardous (Classified) Locations Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. EGS/Appleton Electric.
b. Killark.

2. Description: Pin and sleeve receptacle with matching connector.
3. Class I; Division: As indicated on Plans.
4. Raintight.
5. Standards: Comply with NEMA FB 11 and UL 1203.

2.5 TWIST-LOCKING RECEPTACLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Twist-Lock, Single Receptacles, 120 V, 20 A:

1. Configuration: NEMA WD 6, Configuration L5-20R.
2. Standards: Comply with UL 498.

C. Twist-Lock, Single Receptacles, 250 V, 20 A:

1. Configuration: NEMA WD 6, Configuration L6-20R.
2. Standards: Comply with UL 498.

2.6 TOGGLE SWITCHES, 120/277 V, 20 A

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Premise Wiring.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

B. Single-Pole Switches, 120/277 V, 20 A:

1. Standards: Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 20 A:

1. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 20 A:

1. Standards: Comply with UL 20 and FS W-S-896.

E. Key-Operated, Single-Pole Switches, 120/277 V, 20 A:

1. Description: Factory-supplied key in lieu of switch handle.

2. Standards: Comply with UL 20 and FS W-S-896.

2.7 TIMER LIGHT SWITCH

A. Digital Timer Light Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Sensor Switch
   c. Leviton Manufacturing Co., Inc.

2. Description: Switchbox-mounted, combination digital timer and conventional switch lighting-control unit, with backlit digital display, with selectable time interval in 10-minute increments.
3. Standards: Comply with UL 20.
4. Rated 960 W at 10 A at 120 V ac or 10 A at 277 V ac for LED lighting.

2.8 DIMMERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Leviton Manufacturing Co., Inc.
3. Lutron Electronics Co., Inc.
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Wall-Box Dimmers:

1. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: Continuously adjustable slider; with single-pole or three-way switching.
3. Standards: Comply with UL 1472.
4. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

D. Antimicrobial Cover Plates:

1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Tarnish resistant.

2.10 FLOOR BOXES

A. Refer to Floor Box Schedule on Drawings for additional requirements.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Premise Wiring.
2. Thomas & Betts Power Solutions; ABB Group.
3. Wiremold / Legrand.

C. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

B. Wiring device will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 26 27 26

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 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. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches and enclosed controllers.
2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches.
3. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.6 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.7 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Motor Branch Circuits: Class RK5, time delay.
2. Control Circuits: Class CC, fast acting.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is easily readable without removing fuse.

B. Install spare-fuse cabinet(s) in each electrical room serving fused equipment.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13

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SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Molded-case circuit breakers (MCCB's).
4. Molded-case switches.
5. Generator connection box.
6. Enclosures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D switches or comparable product by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval. It is the sole responsibility of the contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
2. Siemens Energy & Automation, Inc.

B. Type HD, Heavy Duty, Single Throw, 240 and 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NON-FUSIBLE SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D HD series switches or comparable product by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval. It is the sole responsibility of the contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
2. Siemens Energy & Automation, Inc.

B. Type HD, Heavy Duty, Single Throw, 240 and 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D I-Line Style bolt-on molded case circuit breakers or comparable product by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval. It is the sole responsibility of the contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
2. Siemens Energy & Automation, Inc.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents indicated on the drawings.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits in each pole. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger, adjustable from the front.

D. Construct with over center, trip-free toggle type operating mechanisms with quick make, quick break action and positive handle trip indication. Construct breakers for mounting and operating in any physical position. Provide breakers lugs AL/CU rated. Lugs shall be adequate to accept wire size indicated on the drawings.

E. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

F. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

G. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA or more trip and hold below 4mA of ground fault current). One way circuit length shall not exceed 250 feet. If length exceeds 250 feet, notify engineer in writing prior to installing circuit.

H. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip). Provide as noted on plans and/or panel schedules and for all circuits supplying power to heat trace.

I. Interrupting ratings shall be as indicated on drawings. Circuit breakers shall be fully rated for available fault current. Series rating is not acceptable.

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

4. Provide the following where noted on the drawings or schedules:

   a. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered for solid state type trip units and remote-mounted and powered for magnetic type trip units with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   b. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

2.4 GENERATOR CONNECTION BOX

A. Basis-of-Design Product: Subject to compliance with requirements, provide Union Connector Generator Connection Box or comparable product by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval. It is the sole responsibility of the contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
2. Siemens Energy & Automation, Inc.

B. General Requirements: A UL-Listed generator connection panel that shall provide a safe means of connecting a temporary power source to critical loads in a facility.

1. Enclosure: NEMA 3R, fabricated from galvanized steel and powder coated gray in color.
2. Ratings: Ampacity 600A, 277/480V, 3P, 4W + ground.
3. Mounting tabs for surface mounting.
4. Drip Shield
5. Hinged front door with latch able to accept padlock.
6. Bottom of the enclosure shall contain a hinged door for entry of portable cables. The door shall be secured by a latch accessible only from inside the enclosure.
7. Dimensions: 30”H x 24”W x 10”D.
8. Dead front cover shall prevent access to the internal electrical components when the main access door is open.
9. Series 16 CAM inlets shall be mounted on a n internal dead front inlet panel and shall accept standard E1016 type connectors.
10. The Ground inlet shall be wired to the enclosure frame and a Ground connection lug shall be provided for contractor termination of the building ground wire.
11. A warning label to specify the proper sequence for connection and removal of portable cable and shall be mechanically fastened to front cover of the enclosure.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Other Wet or Damp Indoor Locations: NEMA 250, type 4.
d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: NEMA 250, type 12.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Circuit breakers and molded case switches shall be factory installed in enclosures.

E. Comply with NECA 1.

F. Disconnect switches, located at motors controlled by an adjustable frequency drive shall be provided with a late make, early break auxiliary contact rated for ten amps continuous duty. This auxiliary contact shall be wired into the VFD emergency shutdown (coast to stop) circuit to ensure shutdown of the VFD in the event of the disconnect being opened.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

F. Test and/or permanently record the following:

1. Fuses:

a. Equipment nameplate requirement.
b. Actual fuse rating.

2. Circuit Breakers:

a. Nameplate data.
b. Actual trip setting.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION 26 28 16

SECTION 26 29 13

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.

B. All VFDs shall be furnished by Divisions 22 and 23, except as specifically noted elsewhere in these specifications or equipment wiring schedule. Where VFD's are furnished by Division 22 or 23 Contractor, they shall be installed by Division 26 Contractor, coordinated with Division 26 Contractor, connected by Division 26 Contractor, and furnished in accordance with Division 26 Sections of the specifications.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. 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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.

1.6 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. 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.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. Do not store in areas subject to weather.

C. Protect motor starters against damage from work of other trades.

1.9 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

D. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval. It is the sole responsibility of the Contractor to ensure that any submittals made are for products that meet or exceed the specifications included here.

1. Square D; a brand of Schneider Electric.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.

2.2 FULL-VOLTAGE MANUAL CONTROLLERS AND SWITCHES

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Configuration: Nonreversing.
2. 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.
3. Red pilot light to indicate motor running.

2.3 COMBINATION FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Combination Magnetic Controllers: Factory-assembled combination of a full voltage, across the line, electrically held, magnetic controller, OCPD, and disconnecting means.

1. Configuration: Nonreversing.
2. Contactor Coils: Pressure-encapsulated type.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
4. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. Minimum CPT Size: 50VA.
    b. CPT Spare Capacity: 50VA.

5. Solid-State Overload Relay:

    a. Switch or dial selectable for motor running overload protection.
    b. Sensors in each phase.
    c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

6. MCP Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Short Circuit Rating:

   a. The short circuit current rating of the combination starter shall be the same as the upstream overcurrent protection device protecting the starter.

2.4 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: Type 1.
   b. Other Wet or Damp Indoor Locations: Type 4.
   c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: Type 12.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

   a. Pilot Lights: LED types; Red to indicate motor running; push to test.
   b. Selector Switches: Rotary type; 3 position (Hand, Off, Automatic).
   c. External overload reset push button.

2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3. Auxiliary contacts "a" and "b" arranged to activate with MCP handle to disconnect external control power when starter door or cover is opened.
4. N.O. alarm contact that operates only when MCP has tripped.
5. N.O., isolated overload alarm contact.

B. Two N.C. and two N.O. auxiliary contact(s).

C. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

D. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

E. Cover gaskets for Type 1 enclosures.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Manual Controllers: Flush mount in wall

B. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller 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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each component, enclosed controller, component, connecting supply, feeder, and control circuit in accordance with the latest version of the NETA Acceptance Testing Specification Chapter 7.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection 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.
9. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

E. Enclosed controllers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

3.7 PROTECTION

A. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 26 29 13

SECTION 26 31 00
PHOTOVOLTAIC SYSTEM PERFORMANCE REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes general performance requirements that apply to installing a roof mounted solar electric (PV) system for this project
B. Contractor is the Designer of Record for this system. Contractor is required to provide a Structural PE (Professional Engineer) Stamp for the structural design and an Electrical PE Stamp for the overall system design.
C. Both the structural and electrical stamps are to be provided from experienced PV designers with at least 5 similar completed projects.
D. Contractor is required to have experience with at least 5 similar completed PV projects.
E. Product specifications included in this section are the Basis for Design. Design substitutions shall meet the minimum performance requirements defined in this section. Contractor shall select number of inverters and perform string sizing.
F. Related Work and Requirements:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

G. Incentive Paperwork:

1. Contractor to provide support with Owner's application for Focus on Energy incentives.

1.2 DEFINITIONS

A. MPPT: Maximum power point tracking.
B. STC: Standard test conditions, 1000 W/m2, 1.5 air mass, and 25°C cell temperature.
C. NABCEP: North American Board of Certified Energy Practitioners
D. PTC: PV USA Test Conditions, 1000 W/m2, 1.5 air mass, 20°C air temperature, and 1 meter/sec. wind speed.
E. Voc: Open circuit voltage
F. Isc: Short circuit current.

1.3 SUBMITTALS

A. Experience: Submit resumes for individuals involved with the design and construction of the PV System. Submit references and summaries of five similar projects that these individuals have completed.
B. Product Data: For each type of component indicated below. Include rated capacities, operating characteristics, and furnished specialties and accessories. All product data submittals shall be submitted for review by Owner prior to purchasing any materials or equipment.

1. Solar panels
2. Combiner boxes and fuses
3. Grid tied inverters, including efficiency data.
4. Solar panel structural system, including rail, clamps, and brackets.
5. Manufacturer's installation instructions.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. All shop drawings shall be submitted for review by Owner prior to purchasing any materials or equipment.

1. Dimensioned AutoCAD plan drawings of equipment including solar panel array, inverters, disconnects, combiner boxes, metering, and electrical routing.
2. Provide AutoCAD drafted three-line wiring diagram of solar PV system indicating ratings of all panels and inverters, wire and conduit types and sizes, and disconnects.

3. Wiring Diagrams: Power, signal, and control wiring.

D. Design Calculations

1. The following design calculations shall be performed by Contractor and submitted for review by Owner prior to purchasing any materials or equipment.

a. Electrical calculations, including string sizing, inverter selection, and voltage losses.
b. Structural calculations, including rail spans, wind and snow loading, required ballast weights, and roof strength calculations.

E. Permitting and Agreements

1. The following permits and agreements shall be prepared by Contractor on behalf of the Owner. All approved permits and agreements shall be submitted for review by Owner prior to purchasing any materials or equipment.

a. Utility interconnection agreement
b. Building permit
c. Electrical permit

F. As built drawings:

1. Dimensioned AutoCAD plan drawings of equipment including solar panel array, inverters, disconnects, combiner boxes, metering, and electrical routing.
2. Provide AutoCAD drafted three-line diagram of solar PV system indicating ratings of all panels and inverters, wire and conduit types and sizes, and disconnects.

G. Field quality-control test reports.

1. Include voltages and power output for each string. Measure and record solar intensity during testing. Include time, date, and weather conditions of test.

H. Operation and Maintenance Data: For panels, inverter, metering, and monitoring. In addition to items specified in Division 01 include the following:

1. Instructions for operating equipment.
2. Identification of operating limits which may result in hazardous or unsafe conditions.
3. Document ratings of equipment and each major component.
4. Technical Data Sheets.
5. Wiring Diagrams.
6. Parts list.

I. Warranty: Copies of all manufacturer’s and installer’s warranties.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
2. Installer must have PV Installer certification through NABCEP.

B. Source Limitations: Obtain panels from a single manufacturer, of a single type and rating. Obtain inverters from a single manufacturer, of a single type and a single rating.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. Comply with NFPA 70 and all applicable state and local codes

1.5 COORDINATION

A. Coordinate metering and interconnection agreement with electric utility. Contractor shall pay all interconnection fees including the application review fee, engineering review fee, and distribution system study fee. Contractor shall submit all required forms to utility.

1.6 WARRANTY

A. Installer must provide a two year installation warranty covering any defects of the installation.
B. Panel Warranty Period:

1. 5 years workmanship warranty.
2. 10 year 90% linear power output warranty.
3. 25 year 80% linear power output warranty.

C. Inverter Warranty Period: 15 year warranty.

PART 2 - PRODUCTS

2.1 SOLAR PANELS

A. Available Manufacturers: Subject to compliance with performance requirements, manufacturers offering products that may be incorporated into the Work include:

1. Heliene
2. Solarworld
3. LG
4. Hanwha Q-cells
5. Canadian Solar

B. If an alternate product is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.
C. Capacities and Characteristics:

1. All panels shall be of a single type from a single manufacturer.
2. Power Output Ratings: STC rated power of 300 watts.
3. DC Array size of 99.9 kW.
4. AC Energy Produced 126,445 kWh/yr based on the following assumptions:

a. http://pvwatts.nrel.gov/pvwatts.php (PV Watts version 1)
b. Module Type: Standard
c. Array Type: Fixed (roof mount)
d. System Losses: 14%
e. Tilt: 37 degrees
f. Azimuth: 135 degrees
g. DC to AC Size Ratio: 1.1
h. Inverter Efficiency: 96%
i. Ground Coverage Ratio: 0.4

5. Power tolerance of less than 5% variation (maximum minus minimum). Minimum tolerance of -0%.
6. Manufactured in the U.S., Mexico or Canada
7. Nameplates: To identify electrical characteristics, manufacturer's name and address, and model and serial number of component.

8. Module efficiency: minimum 17.00%
9. 60-cell

D. Materials and construction

1. Monocrystalline or Polycrystalline
2. Junction box with bypass diodes.
3. Output Connections: Factory wired separate positive and negative leads sized per division 26 wire requirements with locking quick disconnects, rated for use in direct sunlight. Shall meet all requirements of NEC article 690.33.
4. Anodized aluminum frame with drainage holes and grounding holes.
5. Operating temperature range of -40°C to +85°C.
6. Withstand 1" diameter hail at 50 mph without damage.
7. Load rated at 5400 Pa (113 psf) when used with two rail system.

2.2 INVERTERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:

1. Solar Edge with P850 Optimizers (1 Optimizer per 2 panels) – Basis of Design
2. Fronius
3. SMA

B. If an alternate product is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.

C. Standards

1. IEEE 1547
2. UL 1741 – anti-islanding.

D. Electrical characteristics

1. AC kW rating: Minimum DC-to-AC ratio of 1.0

   a. Provide (3) inverters rated for a total of 99.9 kW DC input

2. Output voltage: 277V/480Y VAC (-12%, +10%), 3 phase, 4-wire.
3. Frequency: 60 Hz sine wave
4. Input voltage: Coordinated with solar array.
5. Max Voc: Coordinated with solar array.
6. Max DC current: Coordinated with solar array.
7. Startup voltage: Coordinated with solar array.
8. Output power factor: Unity
9. DC to AC conversion efficiency:

   a. 97.5% CEC rated efficiency

10. A/C and D/C rapid shutdown compliant with NEC 2017

E. Features

1. Transformerless design.
2. Forward facing DC disconnect
3. DC side ground fault protection.

4. Inverter must limit power output to nameplate value. If connected to an array capable of producing more than the inverter's capacity, the inverter must limit the power without damage.
5. Maximum power point tracking over the range of voltages of the array, at the ambient temperatures of the site.
6. User navigable display.
7. LED status lights on enclosure.
8. Communication port for diagnostics and communication port for communication with multiple inverters and internet interface device.
9. NEMA 3R enclosure

2.3 PV WIRING

A. Type PV-WIRE, #10AWG, from array to combiner box, and where used as a jumper for connection between panels.
B. UV-Stabilized Cable Ties:

1. Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
2. Minimum Width: 3/16 inch (5 mm).
3. Tensile Strength at 73 °F (23 °C), According to ASTM D 638: 12,000 psi (82.7 MPa).
4. Temperature Range: -40 to +185 °F (-40 to +85 °C).
5. Color: Black.

C. Ampacity of PV source circuits shall be a minimum of 156% of the sum of parallel strings short circuit currents.

1. Shall be sized to limit voltage drop to 1.5% from array to inverter during full production at MPPT voltage at maximum ambient temperature.
2. Shall be in metallic conduit from combiner box, if installed, to inverter.

2.4 COMBINER BOX

A. If needed, Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:

1. Blue Oak
2. SMA
3. MidNite solar

B. If an alternate product is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.
C. Capacities and Characteristics:

1. DC current and voltage ratings coordinated with array.
2. Positive and negative combiner blocks.

a. Number of poles coordinated with array.

3. Disconnect switch.
4. DC voltage fuses in fingersafe fuse holder.

D. Materials and construction

1. Powder coated steel, NEMA 3R enclosure.
2. Knockouts
3. Stainless steel hardware.

2.5 RACKING & ROOF ATTACHMENT & ROOF PENETRATIONS

A. Tilt Angle of Panels: 37 degrees from horizontal
B. Manufacturers: Iron Ridge.

1. Products for pitched roofs:

a. S-5 Clamps (for standing seam installations)

1.) Use S-5-U, S-5-S, or the required clamp for the specific roofing product.
2.) S-5 mini clamps are not acceptable.

2.6 INTERNET BASED MONITORING

A. Provide standard package from inverter manufacturer and connect to the City Network. Coordinate with Owner. Contractor is required to test monitoring to confirm it is functioning.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of electrical connections. Verify actual locations of connections before panel installation.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ARRAY REQUIREMENTS

A. Install panels on racking designed for solar (PV) panels.
B. Coordinate installation with roof shop drawings.
C. Structural Performance: Installation shall withstand all local wind and snow loads, and all local building department requirements.
D. If applicable, slip sheet is to be used between ballasted racking and roof membrane
E. All fastening hardware must be stainless steel.
F. All materials must be metallurgically compatible where different materials are in contact with each other.
G. Roof penetrations shall be made watertight using methods that are standard to the roofing industry, are approved by the roofing manufacturer, and that protect the warranty of the roof.
H. The panels shall be connected in arrays with the following characteristics:

1. Total DC peak STC rated power of all panels in the array shall be minimum 99.9 kW. The panels shall be divided into even arrays between the inverters.
2. The panels shall be installed only in the area outlined on the architectural roof drawing.
3. If an alternate layout is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.
4. If needed, each array shall be provided with a combiner box.
5. The panels shall be installed with long axis running west/east as shown on electrical roof drawing.
6. PV panel cables may be installed exposed where routed directly behind panels, but all cables shall be installed in a section of conduit where crossing part of the roof not under a panel. Conduit running across roof shall be supported on roof using Cooper B-Line Dura-Blok or equivalent.
7. All PV panel cables shall be installed in a neat and workmanship like manner. Excess wire shall be coiled and bundled neatly and supported securely in an area where they are not subject to environmental degradation, such as from wind, sun, and animals. Attach PV panel cables to racking with zip-ties listed for use in direct sunlight.
8. Panels shall be connected in series and parallel to match voltage and current ratings of inverter, across all ambient temperatures common to site (-25°C to 40°C).

a. Open circuit voltage of array on coldest day of year in full sunlight shall not exceed maximum operating voltage rating of inverter, panels, or any other equipment.

b. Open circuit voltage on warmest day of year in morning sunlight conditions (200W/m2 irradiance) shall exceed inverter startup voltage. Voltage under operating MPPT conditions, minus any voltage drop over conductors, shall exceed minimum inverter input voltage.
c. Available short circuit current multiplied by 1.25 shall not exceed ratings for the inverter or any panels.
d. All series strings of panels shall have same performance characteristics.

3.3 ELECTRICAL INSTALLATION

A. Ground equipment according to Division 26

1. Size grounding conductors per NEC articles 250 and 690.
2. All conductive equipment enclosures must be grounded.
3. All panel frames must be grounded.

a. The removal of any panel shall not interrupt a grounded conductor to another photovoltaic source circuit.

B. Install wiring, combiner boxes, conduit, disconnects, inverter, web based monitoring hardware, sensors and other equipment according to Division 26.
C. Connect wiring according to Division 26.

3.4 IDENTIFICATION

A. Identify and label system components according to Division 26.

1. Provide a unique label for each inverter, PV output circuit, combiner box, PV Source circuit, and panel. Labeling shall match labeling shown on as-built diagram and plan provided by contractor.

B. Provide all labeling required by NEC article 690, including, but not limited to:

1. Label disconnects capable of being energized from both directions as such.
2. Provide plaque at utility service disconnect per article 690.56B. Field verify exact location.
3. Label each photovoltaic disconnecting means per NEC article 690.53.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections as indicated below and prepare test reports. Correct any deficiencies.

1. Visually inspect all connections.
2. Visually inspect all supports.
3. Measure Voc of each individual string of panels under full sunlight.

a. Verify Voc of all strings are balanced.
b. Verify measured Voc against calculated Voc for the ambient temperature. Extrapolate Voc to temperatures expected at site, and verify they are within inverters ratings.

4. Measure Isc of each string of panels.
5. Verify correct operation of inverter.
6. Verify correct operation of complete system.
7. Replace any defective panels. Panels shall be replaced at contractor's expense.

3.6 DEMONSTRATION

A. Simulate power outage by interrupting normal source, and demonstrate that system disconnects from utility.

B. Provide owner's maintenance personnel with minimum two-hour training session and in compliance with Div 1 Training Requirements.

1. Provide training on function of each piece of equipment.
2. Provide training on maintaining the system.
3. Explain means of disconnecting the system, and principals of operation and safety.

END OF SECTION 26 31 00

SECTION 26 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 REFERENCE CODES AND LISTINGS

A. National Fire Protection Association (NFPA) – The latest adopted edition of the code referenced:

1. NFPA 1 – National Fire Code
2. NFPA 13 – Standard for the Installation of Sprinkler Systems
3. NFPA 70 – National Electrical Code
4. NFPA 72 – National Fire Alarm Code
5. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems
6. NFPA 101 – Life Safety Code

B. Federal Guidelines for Accessibility for Americans with Disabilities

C. Building Code - 2015

D. Approval from the Office of the State Fire Marshall.

E. The system as a whole and the individual system components shall comply with applicable listings of Underwriter's Laboratories (UL), including but not limited to the following.

1. UL864/UOJZ, APOU – Control Units for Fire Protective Signaling Systems
2. UL 268A – Smoke Detectors for Fire Protective Signaling Systems
3. UL268A – Smoke Detectors for Duct Applications
4. UL 228 – Door Holders for Fire Protective Signaling Systems
5. UL 464 – Audible Signaling Appliances
6. UL 1638 – Visual Signaling Appliances
7. UL 38 – Manually Activated Signaling Boxes
8. UL 346 – Water flow Indicators for Fire Protective Signaling Systems
9. UL 1971 – Standard for Signaling Devices for the Hearing Impaired
10. UL 1481 – Power Supplies for Fire Protective Signaling Systems
11. UL 521 – Heat Detectors for Fire Protective Systems

1.3 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire alarm pullstations.
3. System smoke detectors.
4. Intelligent addressable heat detectors.
5. Notification devices.
6. Magnetic door holders.
7. Remote annunciator.

8. Addressable interface devices
9. Water flow detector pressure switches
10. Sprinkler supervisory switches
11. Dual Path Communicator
12. Device guards

B. Related Sections include the following:

1. Division 26 Section “Low-Voltage Electrical Power Conductors and Cables”
2. Division 26 Section “Grounding and Bonding for Electrical Systems”
3. Division 26 Section “Raceways and Boxes for Electrical Systems”

1.4 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.5 SYSTEM DESCRIPTION

A. Furnish and install a complete UL certified, non-coded, point addressable, intelligent Fire Alarm System as described herein and as shown on the plans.

B. System shall be dedicated to fire service only.

C. The fire alarm control unit shall have an operator interface to allow for loading or editing special instructions and system operating sequences as required. The system shall be capable of on site programming to accommodate and facilitate expansion, building parameter changes and changes as required by local codes. All software operations are to be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the system programs stored in memory.

D. The fire alarm control unit shall allow for operator to set detector sensitivity ratings for each device, within code allowed parameters.

E. To accommodate and facilitate job site changes, initiation circuits shall be individually configurable on site to provide either alarm/trouble operation, alarm only, trouble only, current limited alarm, no alarm, normally closed device monitoring, a non-latching circuit or an alarm verification circuit.

F. All control equipment shall have transient protection devices to comply with UL864 requirements.

G. Fire alarm control unit shall accept addressable analog detectors and addressable monitor modules for dry contact devices.

H. Bypass switches shall be included for system testing to prevent audible/visual signal operation, HVAC control activation, and remote fire department notification. Bypass switches for fire alarm system testing shall be located in main fire alarm control unit. Activation of bypass switches shall cause system trouble alarm.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits.

3. Include 25% spare capacity on each signal circuit so that additional devices can be added.
4. Include substantiating emergency (battery) and normal power supply calculations for supervisory and alarm power requirements and calculations of notification device circuit loading (end of circuit voltage drop) to ensure proper operation of all devices.
5. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits. Drawing scale shall match engineers design drawings.
7. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
8. Include complete schematic circuit diagrams for system, including all equipment. Wiring diagram shall show point to point connections between all system components
9. Include descriptions of system operation, annunciator schedule showing titles for each zone, and manufacturer's literature marked to show model and catalog number for all equipment.
10. Include complete riser diagrams for system indicating wiring sequence of all alarm devices and control equipment shall be included with submittal data.

C. General Submittal Requirements:

1. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified fire-alarm technician, Level III minimum.

D. Wisconsin Department of Commerce – Fire Alarm System Plan Approval.

1. Where fire protection system plan approval is required, the contractor shall assist the Engineer in the preparation of the submittal. Refer to State Register April 2003, Department of Commerce Code, Chapter 61, paragraph 61.30(3) and table 61.30-3 for buildings where fire protection system plan approval is required. Submittal requirements and areas of responsibility are as follows:

    a. Fire Alarm System Floor Plans dimensioned and drawn to scale with appropriate symbols, system wiring requirements, and other information required by the Department of Commerce. Four sets required to be furnished to the Engineer by the electrical contractor.
    b. Copy of the fire alarm system control unit and device shop drawings. Four sets required to be furnished to the Engineer by the electrical contractor.
    c. Fire alarm system voltage drop calculations and standby battery calculations. Four sets required to be furnished to the Engineer by the electrical contractor.
    d. One set of fire alarm system specifications. Provided by the electrical engineer.
    e. Additional information required by the Department of Commerce relating to the specific system to be installed, system wiring requirements, calculations, or other components shall be furnished to the engineer by the electrical contractor. Costs associated with this shall be included in the contractor's bid.
    f. Application for Approval to be completed and submitted by the Engineer.
    g. Permit approval fees.

2. Contractor shall note that fire alarm system shall be submitted and approved prior to the installation of the system.

E. Systems Contractor Qualifications.

1. The contractor directly responsible for this work shall be a systems contractor, who is and who has been regularly engaged in the furnishing and installation of commercial and industrial fire alarm systems of this type and size for at least the immediate past 5 years. All equipment shall be installed by a technician trained by the equipment manufacturer or a recognized training school or course for the installations of this type system. The contractor shall, if requested by the engineer, show proof of a specific individual's

training. The system's contractor shall directly employ a suitable number of skilled systems installers whose normal work is systems installation and who shall install and make the wire and cable connections thereto.

2. As part of the project submittal, it shall be demonstrated to the satisfaction of the engineer that the systems contractor has adequate plant and equipment to do the work properly and expeditiously, adequate staff and technical experience.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Detailed description of equipment anchorage Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

    a. Frequency of testing of installed components.
    b. Frequency of inspection of installed components.
    c. Requirements and recommendations related to results of maintenance.
    d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

C. The Contractor shall provide three bound copies of the following, to be forwarded to the Owner at completion of project:

1. As-built wiring and conduit layout diagrams showing all fire alarm devices on floor plans, including wire color code and terminal numbers, and showing all interconnections in the system.
2. Electronic circuit diagrams of all FACP modules, power supplies, annunciator, data gathering panels, addressable interface modules, etc.
3. Technical literature on all major parts of the system, including control panels, smoke detectors, batteries, manual stations, alarm notification appliances, power supplies, and remote alarm transmission means.

1.9 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. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools: One extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: Three of each type installed.
7. Fuses: Two of each type installed in the system.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. The addressable fire alarm system shall be connected, programmed, and tested only by the manufacturer or by an authorized distributor who stocks a full complement of spare parts for the system. Technicians performing this service shall be trained and individually certified by the manufacturer for the model of system being installed. Copies of their certifications must be included with the contractor's submittal to the engineer, prior to installation. The submittal cannot be approved without this information.

D. System equipment shall be from a single manufacturer and shall be supported by a manufacturer authorized, established service organization that shall stock parts for the equipment supplied.

E. Equipment shall be manufactured by a firm that has been actively manufacturing fire alarm systems for a minimum of 7 years and that offers a 3 year warranty on all control equipment.

F. 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.

G. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.11 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Receive equipment at jobsite; verify applicable components and quantity delivered per invoice.

B. Handle equipment to prevent internal components damage, breakage, denting, and scoring enclosure and finish.

C. Do not install damaged equipment.

D. Store equipment in a clean, dry space and protect from dirt, fumes, water, construction debris, and physical damage.

E. After installation, protect from damage by work of other trades.

1.12 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service:

1. Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
2. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.13 WARRANTY

A. Manufacturer's standard form in which manufacturer agrees to repair or replace components of system and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Manufacturer’s standard warranty period (minimum one year) from date of start-up.
2. Labor and travel time for necessary repairs at the job site shall be included.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Edwards Systems Technologies (EST) or comparable product by one of the following. The listing of a manufacturer as “acceptable” does not imply automatic approval.

1. NOTIFIER; a Honeywell company.
2. Siemens Building Technologies, Inc.; Fire Safety Division.
3. Simplex-Grinnell LP; a Tyco International company.
4. Wheelock (Where Noted - Notification Devices Only)

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Fire-extinguishing system operation.
7. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate alarm communication system.
7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
8. Record events in the system memory.
9. Record events by the system printer.
10. If fire alarm activation is caused by a duct smoke detector, the following actions shall be initiated:

    a. Shut down associated air handling system.
    b. Close all smoke dampers in ducts associated with the air handling unit.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Sprinkler tamper switches.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System installation shall allow remote restarting of all air handling systems after having been shut down by the Fire Alarm System. Air handling systems shall automatically restart after fire alarm system has been reset.

F. Smoke dampers in ducts shall close whenever associated air handling system is shut down either by fire alarm system activation or otherwise.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.

    a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
    b. Include a real-time clock for time annotation of events on the event recorder and printer.

2. Addressable initiation devices that communicate device identity and status.

    a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
    b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 2 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.

    a. Initiating Device Circuits: Style B.

b. Notification Appliance Circuits: Style Y.
c. Signaling Line Circuits: Style 4.
d. Provide 25% spare capacity on circuits for additional devices.

2. Serial Interfaces: Two RS-232 ports for printers.

D. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

E. Power Supplies:

1. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and dual path communicator shall be powered by 24-V dc source.

a. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

2. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

a. Batteries: Sealed lead calcium.

3. After 24 hours, the battery backup supply shall be capable of energizing all signal devices for a period of at least five minutes. In addition, the low battery backup supply monitor shall supervise and automatically sound System Trouble in the event that a trouble occurs in the system (i.e., the batteries being disconnected or discharging to 85% of full charge). Battery and power supply capacity shall provide an additional 25% spare capacity for additional alarm signal devices that may be added to the system.
4. Provide power supply and battery capacity for system operation. Power supply and battery capacity shall be sized to allow an additional 25% spare capacity for future growth. The power supply shall be able to perform an automatic load test of batteries and indicate a trouble condition if the batteries fall outside a predetermined range. Power supplies shall incorporate the ability to adjust the charge rate of batteries based on ambient temperatures. Exact locations and quantities of power supplies shall be as determined by the contractor.

F. Surge Protection Devices

a. The system shall be provided with the following protective devices to prevent damage of nuisance alarms by nearby lightning strikes, stray currents, or voltage transients. They are to be provided by the fire alarm equipment supplier:

1) On AC Input: Ditek DTK-120HW or DTK-120/240 CM, EFI HWM-120, Leviton OEM-120EFI, Transtector ACO100BWN3, or equal UL Listed device approved by NCDoI. Installed at the electrical panelboard, and trim excess lead lengths. Wind small coil in the branch circuit conductor just downstream of the suppressor connection. Coil to be 5 to 10 turns of about 1" diameter, and tie-wrapped.
2) On DC circuits Extending Outside Building: Adjacent to the FACP, and near the point of entry to the outlying building, provide a “pi” filter on each leg. This consists of a primary arrestor, a series impedance of 1 millihenry or more, and a fast acting secondary arrestor which clamps between 30 and 40 volts. Acceptable models with these or equivalent features include Simplex 2081-9027 and 2081-9028, Transtector TSP8601, Ditek DTKxLVL series, Citel American B280 -24V, Edco P264 and P642, or equal. Submit specification on other candidate suppressors for approval.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
5. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
    c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Provide remote indicator alarm for each duct detector. Mount on ceiling in corridor nearest to duct detector location.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, equipped for mounting as indicated and with screw terminals for system connections.

1. Device Color: Factory finished, coordinate red/white coloring with Architect.
2. Devices shall be flush mounted with surface.
3. Strobes shall be set at 75 candela, unless otherwise noted on drawings.
4. Exterior mounted devices shall be provided with flush mounted weatherproof backbox.

B. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Rated Light Output:

   a. 15/30/75/110 cd, field selectable and synchronized.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

1. Horn shall have field selectable high and low db output and field selectable temporal or steady output.

D. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

1. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

2.8 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. All holders shall be normally be energized, and a release shall be accomplished by interrupting the circuit.
4. Rating: 24-V dc.

B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Air Handling System Shutdown Relays: Provide and install a supervised addressable output relay at each Air Handling System for shutdown on alarm from fire alarm system as per system operation description. The unit shall be normally closed with a coil to match voltage of Fire Alarm Control Panel and interrupt starting circuit of Air Handling System unit fan(s). Provide and install a supervised addressable output relay at each exhaust fan for shutdown on alarm from fire alarm system as per system operation description, unless exhaust fan is interlocked with AHU.

C. Waterflow Detector/Pressure Switches: Waterflow or pressure switches to be supplied and installed by the fire protection system contractor and wired to the Fire Alarm System by this Contractor. Provide addressable water flow/tamper module for each switch so that each switch can be individually monitored.

2.11 DUAL PATH COMMUNICATOR

A. Dual path communicator shall be acceptable to the remote central station and shall comply with UL 864 and be listed and labeled by an NRTL. Basis of Design Bosch B465 Universal Dual Path Communicator.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically dial a preset number for a remote central station. The communicator converts the Public Switch Telephone Network (PSTN) digital dialer, or dry contact outputs from a fire control panel to an IP signal for transmission over Ethernet or cellular network (provide plug-in module). When contact is made with central station(s), signals shall be transmitted. If service on either communication network is interrupted for longer than 45 seconds, communicator shall initiate a local trouble signal and transmit the signal indicating loss of communication line to the remote alarm receiving station over the remaining line. If service is lost on both communication lines, communicator shall initiate the local trouble signal.

C. Local functions and display at the dual path communicator shall include the following:

1. Verification that both communication lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data communication shall include the following:

1. Address of the alarm-initiating device.
2. Address and/or Zone of the supervisory signal.
3. Address and/or Zone of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. All wiring shall be installed in conduit. Flexible connectors shall be used for all devices mounted in suspended lay-in ceiling panels. All conduit, mounting boxes, junction boxes and panels shall be securely hung and fastened with appropriate fittings to insure positive grounding throughout the entire system.

C. No wiring other than that directly associated with fire alarm or auxiliary fire protection functions shall be permitted in fire alarm conduits. There shall be NO splices in the system other than at terminal blocks. “Wire nuts” and crimp splices are NOT permitted. Permanent wire markers shall be used to identify all terminations for each circuit. For splices, use markers or other means to indicate which conductor leads to the FACP. All connections shall be made on terminal strips. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type. No more than two conductors under one connection. Wire on these terminals shall be labeled. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end with "E-Z markers" or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded. All controls, function switches, etc., shall be clearly labeled on all equipment panels. All wiring shall be checked and tested to insure that there are no grounds, opens or shorts.

D. All wiring shall be color coded in accordance with the following scheme, which shall be maintained throughout the system, without color change in any wire run:

1.	Initiating Circuits	Yellow(+)/Brown (-)
2.	Alarm Indicating Appliance Circuits	Red(+)/Blue (-)
3.	AHU Shutdown Circuits	Orange
4.	Door Control Circuits	Gray
5.	Elevator Capture Circuits	Violet
6.	Exception: Addressable initiating circuits shall comply with Paragraph below.	

E. Wire shall be 14 AWG minimum, stranded or solid copper, type THHN or THWN except for addressable loop controller circuits. Addressable loop controller circuits are to be wired with type FPL/FPLR/FPLP fire alarm cable, solid copper, AWG 18 minimum, twisted pair, installed in conduit, instead of AWG 14 THHN/THWN stranded

conductors. Provide shielded cable if required by manufacturer. If shielded cable is required by manufacturer, cable shield drain wires are to be connected at each device on the loop to maintain continuity, and taped to insulate from ground. Terminate the shield at the FACP in accordance with the manufacturer's instructions. The cable shall have red jacket, with yellow (+) and brown (-) conductors.

F. All addressable loop controller circuits shall have a minimum of 25% spare addresses for future use. "T" taps from the loop are permitted, but only if they serve no more than 30 initiating devices and/or control points, in an area which does not exceed approximately half of one story. To minimize the impact of a wiring fault on the system, isolation modules must be provided as follows:

1. After each 30 devices/control points on any addressable circuit, including taps.
2. At each "T" tap which feeds 5 or more devices/control points.
3. For each circuit extending outside the building.
4. All isolation modules must be clearly labeled, readily accessible for convenient inspection, and shown on the as-builts.

G. Initiating device or indicating appliance circuits must not be included in raceways containing AC power or AC control wiring. Within the FACP panel, any AC control wiring must be properly separated from other circuits. The enclosure must have an appropriate warning label to alert service personnel to the hazard.

H. A unique identification number shall be assigned to each detector. (Identification shall be by zone number and device number within the zone.) This number shall be noted on the submittals and as-built plans, and also be permanently mounted adjacent to the detector or affixed to its base.

I. Install wall-mounted equipment, with tops of cabinets not more than 72 inches above the finished floor.

J. Smoke- or Heat-Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
5. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

K. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Provide weatherproof enclosures for any duct smoke detector installed outdoors.

L. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

M. Annunciator: Install with top of panel not more than 46 inches above the finished floor.

3.2 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
2. Smoke dampers in air ducts of designated air-conditioning duct systems.
3. Supervisory connections at valve supervisory switches.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 POWER CONNECTIONS

A. Provide 120 volt, 20 amp circuit to all fire alarm panels, remote panels, terminal cabinets, etc (whether shown on drawings or not). Connect to spare 20 amp, 1 pole circuit breaker in nearest 120 volt panel. Re-label circuit breaker accordingly. Provide locking device on breaker and color breaker red.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
    b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

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SECTION 26 33 23.11

CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following central battery and power conversion equipment rated 600 V and less for emergency lighting:

1. Uninterruptible (UPS-type) central battery equipment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of central battery equipment unit.

1. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, shipping splits, and furnished options, specialties, and accessories.

B. Shop Drawings: For each type and rating of central battery equipment unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, ventilation requirements, method of field assembly, components, and location and size of each field connection.
3. Include system one-line diagram, internal and interconnecting wiring; and diagrams for power, signal, and control wiring.
4. Include elevation, details, and legends of control and indication displays.
5. Include -circuit current (withstand) rating of unit.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around central battery equipment. Show central battery equipment layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each type of central battery equipment.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For central battery equipment to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing central battery equipment.
b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
c. Manufacturer's written instructions for selecting and setting field-adjustable controls and status and alarm points

1.6 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. Deliver extra materials to Owner.

1. Fuses: One for every 10 of each type and rating, but no fewer than 2 of each type.
2. Cabinet Ventilation Filters: One complete set.
3. Circuit Board: One spare circuit board for each critical circuit.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
3. Humidity: More than 95 percent (condensing).
4. Altitude: Exceeding 3300 feet.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for central battery equipment, including clearances between central battery equipment and adjacent surfaces and other items.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:

a. Central Battery Equipment (excluding Batteries): Two year(s).
b. Standard VRLA Batteries:

1) Full Warranty: One year(s).
2) Pro Rata: Nine years.

PART 2 - PRODUCTS

2.1 UNINTERRUPTIBLE (UPS-TYPE) CENTRAL BATTERY EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cooper Industries, Inc.
2. Dual-Lite.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. General Requirements for Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

C. Performance Requirements for UPS-Type Central Battery Equipment:

1. Type: On-line, double conversion.
2. Continuously provide uninterrupted ac power to connected emergency electrical lighting system.
3. Automatic Operation:

a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier and inverter, with battery connected in parallel with rectifier output.
b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
c. If normal power fails, battery continues to supply regulated ac power through the inverter to the load without switching or disturbance.
d. When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier then supplies power to the load through the inverter and simultaneously recharges battery.
e. If battery becomes discharged and normal supply is available, rectifier charges battery. When battery is fully charged, rectifier automatically shifts to float-charge mode.
f. If any element in the rectifier/inverter string fails and power is available at normal supply terminals of system, static transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.

g. If a fault occurs in system supplied by the inverter output, and current flows in excess of the overload rating of the inverter, static transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
h. When fault has cleared, static transfer switch returns the load to inverter output.
i. If battery is disconnected, inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

4. Manual Operation:

a. Turning inverter off causes static transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.
b. Turning inverter on causes static transfer switch to transfer the load to inverter.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus or minus 3 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F and not exceeding 86 deg F.
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F and not exceeding 158 deg F
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F and not exceeding 104 deg F.
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F and not exceeding 104 deg F
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet.
12. Off-Line Overload Capability: [**1.1**] [**1.5**] times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

F. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

a. Normal power available.
b. Status of system.
c. Battery charging status.
d. On battery power.
e. System fault.
f. External fault.

2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

a. Keypad: In addition to required programming and control keys, include the following:

1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:

1) Real-time clock with current time and date.
2) Tests and Events Logs: Record and store up to 25 tests and events:

a) Dates.
b) Times.
c) Durations.
d) Output voltage and currents.

3) Alarm Logs: Record and store up to 50 alarms:

a) Dates.
b) Times.
c) Alarm type.

4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:

a) Input and output voltage (V ac) and output current (A ac).
b) Battery voltage (V dc) and current (A ac).
c) Fault or alarming status (code).
d) Power output (VA).
e) Inverter load (W).
f) Ambient temperature (deg F).
g) System run time (cumulative days).
h) Inverter run time (cumulative minutes).

5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:

a) High/low battery charge voltage.
b) High/low input voltage.
c) Battery nearing low-voltage condition.
d) Battery low voltage.
e) High ambient temperature.
f) Inverter fault.
g) Output fault.
h) Output overload.

3. Remote Signal Interfaces:

a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

1) Fault or status indication.
2) On bypass.
3) Low battery.

b. Communications Interface: Factory-installed hardware and software to enable a remote PC to monitor and display status and alarms.

1) Network Communications Ports: Ethernet and RS-232.

2) Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: 65 kA.

I. Rectifier:

1. Description: Solid state, with the following operational features:

a. Automatically convert incoming ac voltage to regulated dc bus voltage, with less than 2 percent rms ripple voltage with inverter fully loaded and batteries disconnected.
b. Rectified Efficiency: Not less than 97 percent.

J. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 3 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes, with recovery within 3 cycles.
b. Automatically regulate output frequency to within plus or minus 0.05 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.
d. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.
e. Load Power Factor: 0.5 lead to 0.5 lag.

K. Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

L. Batteries:

1. Description: Standard VRLA batteries.

a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

M. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses central battery equipment power circuits (inverter and static transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.

N. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: As scheduled on Drawings; manufacturer's standard ratings based on unit output ratings.

2.2 ENCLOSURES

A. Central Battery Equipment Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

2.3 OPTIONAL AND ACCESSORY FEATURES

A. Factory-Installed Options and Accessories:
1. Audible alarm with silencer switch.

2.4 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate central battery equipment fabricator's quality-control and testing methods.

B. Testing: Test and inspect central battery equipment according to UL 924.

C. Factory Tests: Test and inspect assembled central battery equipment, by a qualified testing agency, according to UL 924. Affix standards organization's label. Include the following:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

D. Central battery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store central battery equipment according to NECA 411.

B. Examine areas, surfaces, and substrates to receive central battery equipment, with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.

C. Examine equipment before installation. Reject equipment that is wet, moisture damaged, or mold damaged.

D. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of central battery equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install central battery equipment and accessories according to NECA 411.

C. Floor-Mounted Central Battery Equipment: Install central battery equipment on 4-inch nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Comply with NECA 1.

F. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 CONNECTIONS

A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between central battery equipment and remote devices. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

3.5 IDENTIFICATION

A. Identify central battery equipment, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label central battery equipment with engraved nameplates.
3. Label each separate cabinet, for multicabinet units.
4. Label each enclosure-mounted control and pilot device.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Acceptance Testing Preparation:

1. Inspect and Test Each Component:

a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
b. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
c. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect central battery equipment, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
2. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
3. Test continuity of each circuit.
4. Verify that input voltages and frequencies at central battery equipment locations are within voltage and frequency limits specified in Part 2. If outside this range, notify Architect before closing input OCPDs.
5. Perform each visual and mechanical inspection and electrical test stated in manufacturer's written instructions and in NETA Acceptance Testing Specification, including specifically those for batteries, battery chargers, and UPS, regardless of the type of central battery equipment provided. Certify compliance with test parameters.
6. Perform a load-duration test at rated voltage and rated output current to verify the correct functional operation of the unit under full-load stable operating conditions for the minimum time limits required by UL 924. Monitor and record ambient temperature and temperatures within the unit.
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.

F. Central battery equipment will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, and other adjustable parts.

C. Adjust the trip settings of thermal-magnetic circuit breakers with adjustable, instantaneous-trip elements; install fuses if not factory installed.

D. Set the automatic system test parameters.

3.9 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace central battery equipment whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain central battery equipment, and to use and reprogram microprocessor-based control, monitoring, and display functions.

END OF SECTION 26 33 23.11

SECTION 26 43 13

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

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. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCE SUPPRESSOR

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Eaton.
2. General Electric Company.
3. Liebert; a brand of Emerson Electric Co.
4. SIEMENS Industry, Inc.; Energy Management Division.
5. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 2.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 240kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

E. SCCR: Equal or exceed 100 kA.

2.3 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

2.4 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 43 13

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SECTION 26 51 00

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures.
2. Exit signs.
3. Lighting fixture supports.

B. Related Sections:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 262726 "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Energy-efficiency data.
4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lumen output identical to those indicated for the lighting fixture as applied in this Project.

    a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
    b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Installation instructions.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.5 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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

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. All lamps shall be new and delivered to the job in sealed cartons protected from dirt and dust during storage on the project. Lamps shall be taken directly from the cartons and installed in the fixture with special care so that they do not become dusty and are not soiled in the operation.

1.7 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.8 WARRANTY

A. Special Warranty for LED luminaires: Manufacturer's standard form, made out to Owner and signed by fixture manufacturer agreeing to replace fixture/module that fail in materials or workmanship. Warranty shall include "finish" warranty against failure or substationally deterioration such as blistering, cracking, peeling, chalking or fading. Warranty shall include replacement for defective or non-starting power supply units and LED source assemblies, which include, but are not limited to, LED packages, LED arrays, LED modules, LED dies, encapsulates and phosphors. Warranty shall include replacement for any LED source assembly, package, array or module, which does not include the power supply, against 10% or more of the individual LEDs in that assembly, package, array, or module failing to illuminate.

1. Warranty Period for interior LED light fixtures: Ten year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. Provide luminaires of the size, type and rating indicated in "Lighting Fixture Schedule", complete with, but not necessarily limited to reflectors, drivers, starters, wiring and any other accessories required for a complete working installation.

B. Luminaire catalog numbers do not necessarily include all accessories and are intended to serve as a guide in defining types and manufacturers of luminaire only.

C. The contractor shall ensure that the luminaire is UL listed for the ambient conditions where installed. Extra compensation will not be permitted for failure to coordinate luminaires with their ambient conditions.

1. Luminaires located exterior to the building and/or in unconditioned damp spaces and under cover from direct weather exposure shall be UL listed as "Suitable for Damp Locations" unless noted otherwise.
2. Luminaires located exterior to the building and/or in unconditioned wet spaces and in direct contact with the weather or in washdown areas shall be UL listed as "Suitable for Wet Locations" unless noted otherwise.

D. Luminaires installed with direct contact with insulation shall have an "IC" rating for direct contact with insulation. Verify if luminaires will be in contact with insulation prior to installation. Notify COR of any conflicts.

E. Gasketing material shall be vinyl or other non-aging type material as approved by COR.

F. Provide proper trim for each luminaire as required for various types of ceiling being installed throughout the project; plaster rings, luminaire ends or caps, suspension units, mounting brackets and/or other accessory parts necessary for a complete luminaire.

G. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

H. Metal Parts: Free of burrs and sharp corners and edges.

I. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

J. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

K. Diffusers:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
b. UV stabilized.

2.3 LED LUMINAIRES

A. LED luminaires shall provide a continuous and controllable light source. Lamp output and dimensions shall be in accordance with contract drawings and specifications. LED luminaire lumen output will be in accordance with the specifications and shall not depreciate more than 20% after 10,000 hours of use. Rated lumen output for LED luminaires to operate in ambient temperature of minus 4 deg F to 122 deg F). Luminaires to have minimum life of 50,000 hours.

B. All LEDs used in the LED luminaires will be of high brightness and proven quality. All LEDs shall be driven digitally with pulse width modulation control to prolong life and maintain consistency of lumen output.

C. All connections to luminaires will be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.

D. Fuse Protections: All power supply outputs will be either fuse protected or PTC-protected as per Class 2 UL listing. All luminaires will have built-in fuse protection. All power supplies will provide for knockouts for conduit connections or clamp-style connection for the low-voltage wiring.

2.4 LED DRIVERS (POWER SUPPLIES)

A. All LED drivers to be compatible with LEDs. All LED luminaires and drivers (power supplies) shall be furnished by single manufacture to insure compatibility.

B. Electric Characteristics (at 77°F ambient temperature)

1. Input Voltage Range - 108V to 132V
2. Efficiency Minimum – 80%
3. Output Current Regulation Range (+/-) 5%A
4. Total Harmonic Distortion (THD) – 20% maximum
5. Power Factor – 0.9 minimum
6. Crest Factor (LED Current) – 1.5 maximum

7. FCC Class B for Conducted EMI
8. FCC Class A for Radiated EMI
9. Drivers life – 50,000 hours minimum

2.5 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. The contractor shall install fixture supports as required to support all lighting fixtures adequately, providing extra steel work for the support of the fixtures if required. Any components necessary for mounting fixtures shall be provided by the contractor.
3. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Owner, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.

2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

D. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Bond fixtures and metal accessories to branch circuit equipment grounding conductor.

G. Exit lights shall be mounted above their respective doors and to clear the door frame, where mounting heights would exceed 10 feet Contractor shall coordinate a new location with Engineer such that sign is mounted at 10’ A.F.F. or less.

H. All fixtures shall be checked and cleaned if necessary prior to installing lamps in fixtures.

I. Contractor shall replace any fixtures that have failed until substantial completion of the project at no additional cost to the Owner.

3.2 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 51 00

SECTION 265600

EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior luminaires.

B. Related Sections:

1. Section 265100 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.2 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lumens and accessories.

    a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Photoelectric relays.
7. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C2, "National Electrical Safety Code."

1.7 WARRANTY

A. Special Warranty for LED luminaires: Manufacturer's standard form, made out to Owner and signed by fixture manufacturer agreeing to replace fixture/module that fail in materials or workmanship. Warranty shall include replacement for defective or non-starting power supply units and LED source assemblies, which include, but are not limited to, LED packages, LED arrays, LED modules, LED dies, encapsulates and phosphors. Warranty shall include replacement for any LED source assembly, package, array or module, which does not include the power supply, against 10% or more of the individual LEDs in that assembly, package, array, or module failing to illuminate.

1. Warranty Period for LED Luminaires: Ten years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: Ten years from date of Substantial Completion.
3. Warranty Period for Color Retention: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 LED LUMINAIRES

A. LED luminaires shall provide a continuous and controllable light source. LED luminaire lumen output will be in accordance with the specifications and shall not depreciate more than 20% after 10,000 hours of use. Rated lumen output for LED luminaires to operate in ambient temperature of minus 4°F to 122°F). Luminaires to have minimum life of 50,000 hours.

B. All LEDs used in the LED luminaires will be of high brightness and proven quality. All LEDs shall be driven digitally with pulse width modulation control to prolong life and maintain consistency of lumen output.

C. All connections to luminaires will be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.

D. Fuse Protections: All power supply outputs will be either fuse protected or PTC-protected as per Class 2 UL listing. All luminaires will have built-in fuse protection. All power supplies will provide for knockouts for conduit connections or clamp-style connection for the low-voltage wiring.

2.3 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, and free of light leakage under operating conditions. Doors shall be removable for cleaning or replacing lenses.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff. Relay with locking type receptacle shall comply with ANSI C136.10. Provide adjustable window slide for adjusting on-off set points.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Fasten luminaire to indicated structural supports.

B. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

C. Pole Base Junction Boxes

1. Boxes shall be NEMA 3R Carlon Nonmetallic Curved Lid J-Boxes or equal. Mount j-box centered in pole base. Locate boxes 90-degrees or 180-degrees from traffic. Install boxes per manufactuer’s recommendations.

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 260533 "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 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 56 00

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SECTION 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This specification section is intended to establish the minimum acceptable common work for all Division 27 specification sections. Individual Division 27 and Division 28 specification sections may have more stringent requirements specific to the particular section.

B. This specification section includes general requirements (part 1) for Division 27 and Division 28 work. Individual Division 27 and Division 28 specification sections will also include general requirements (part 1) for that section as well as product specifications (part 2) and execution (installation) requirements (part 3) for that section.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

B. Division 01 specification sections.

C. Division 27 specification sections.

D. Division 28 specification sections.

E. Additional specification sections as referenced in individual Division 27 and Division 28 specification sections.

1.3 ABBREVIATIONS AND ACRONYMS

A. The following Abbreviations & Acronyms apply to this document and its companion sections for clarification and direction. Some or all may apply to the project. Refer to project drawings for additional abbreviations and acronyms.

A	Ampere
AC	Alternating Current
ACS	Access Control System (refer to Division 28)
A/E	Architect/Engineer
AFF, A.F.F.	Above Finished Floor
AFG, A.F.G.	Above Finished Grade
AV, A/V	Audio Visual
BiCSi	Building Industry Consulting Services International
CATV	Community Antenna Television (a.k.a. 'Cable TV')
CM	Communications cable rated for General Purpose use
CMP	Communications cable rated for use in Plenum areas
CMR	Communications cable rated for use in pathways defined as Risers
DC	Direct Current
DSS	Digital Satellite Service
EC	Electrical Contractor
EIA	Electronics Industry Association
EMI	Electromagnetic Interference
FOC	Fiber Optic Cable
FPD	Flat-panel Display
GC	General Contractor
IDS	Intelligent Display System, Intrusion Detection System
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol

IS	Information Systems
ISP	Internet Service Provider, Inside Plant
IT	Information Technology
LAN	Local Area Network
LED	Light Emitting Diode
LO	LASER-Optimized Multimode (Optical) Fiber (LOMMF)
MMF	Multimode (Optical) Fiber
NEC	National Electric Code
NFPA	National Fire Protection Agency
NIC	Not In Contract
NVP	Nominal Velocity of Propagation
OFNP	Optical Fiber Non-conductive Plenum
OFNR	Optical Fiber Non-conductive Riser
OSP	Outside Plant
PA	Public Address
PoE	Power-over-Ethernet
RCDD	Registered Communications Distribution Designer (BiCSi)
RFI	Radio Frequency Interference, Request for Information
SMF	Single-mode (Optical) Fiber
TC, TSC	Technology Contractor, Technology Systems Contractor
TCP	Transmission Control Protocol
TIA	Telecommunications Industry Association
TO	Telecommunications Outlet
TR	Telecommunications Room
TV	Television
UNO, U.N.O.	Unless Noted Otherwise
UTP	Unshielded Twisted Pair (Cable)
V	Volt
VSS	Video Surveillance System (refer to Division 28)
W	Watt
WAN	Wide Area Network
WLAN	Wireless Local Area Network (LAN)

1.4 DEFINITIONS

A. The following definitions apply to this document and its companion sections for clarification and direction. Some or all may apply to the project.

Authority Having Jurisdiction (AHJ)	The building official, electrical inspector, fire marshal, or other individuals or entities responsible for interpretation and enforcement of local building and electrical codes.
Cabling	A system of telecommunications cables, cords, and connecting hardware that can support the connection of information technology equipment.
Code	A rule or set of rules intended to ensure safety during the installation and use of materials, components, fixtures, systems, premises, and related subjects. Codes typically are invoked and enforced through government regulation.
Backbone	A facility (e.g., pathway, cable, conductors, optical fibers) between any of the following spaces: telecommunications rooms (TRs), telecommunications enclosures (TEs), common TRs, floor-serving terminals, entrance facilities (EFs), equipment rooms (ERs), and common ERs.
Demarcation Point (Demarc)	A point where the operational control or ownership changes. Also, the point of interface between service providers (SPs) and customer facilities. Sometimes referred to as minimum point of entry (MPOE).
Entrance Facility	An entrance to a building for both public and private network service cables, including wireless, mechanical and electrical services, and the entrance point at the building wall, and continuing to the entrance room or space.
Furnish	To purchase, procure, acquire, and deliver complete with related accessories.

Horizontal Cabling	The part of the cabling system that extends from (and includes) the work area telecommunications outlet/connector to the horizontal cross-connect (HC) in the telecommunications room (TR).
Install	To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test, before turning over to the Owner, all parts, items, or equipment supplied by the Contractor.
Provide	To furnish, transport, install, erect, connect, test and turn over to the Owner complete and ready for regular operation.
Raceway	Any enclosed channel designed for holding electrical wires or telecommunications cabling. Raceways include multiple types of conduit and tubing, as well as other types of channels built into the architectural materials, such as floor ducts, wireways, and busways. Cable tray is not considered a type of raceway.
Riser	Vertical sections of cable (e.g., changing from underground or direct-buried plant to aerial plant or from one floor of a building to another). Also, the space used for cable access between floors. See backbone.
Telecommunications Room	A telecommunications space that is generally considered a floor-serving or tenant-serving space that provides a connection point between backbone and horizontal cabling.
Service Provider	The operator of any service that furnishes telecommunications content (transmissions) delivered over access provider facilities.
Standard	A collection of specifications that encompass properties of components, systems, and practices intended to ensure an accepted minimum degree of functionality and longevity (performance). Standards are intended to reflect accepted norms as typically determined either through a balloting process conducted by a nationally or internationally accredited organization or as developed by businesses, industry groups, or governments for their use.
Work Area	A building space where the occupants interact with telecommunications terminal equipment (e.g., an individual office or cubicle, printer/copier room).

B. Clarifications:

1. Where the word “conduit” is used without specific reference to type, it shall be understood to mean “raceway”.
2. Reference to “U.L. (Materials Construction) Standards” shall mean the “Standards for Safety” published by Underwriters Laboratories, Inc.
3. Reference to “NEMA Standards” shall mean the “Approved Standards” published by the National Electrical Manufacturers Association.
4. Reference to “ANSI Standards” shall mean the standards published by the American National Standards Institute.
5. Reference to “IEEE Standards” shall mean the standards published by the Institute of Electrical and Electronics Engineers.
6. Reference to “BICSI Standards” shall mean the guidelines and methods published by the Building Industries Consulting Service International.

1.5 CODES AND STANDARDS REFERENCES

A. All applicable codes and standards shall be as identified in the project code analysis. Where codes or standards are not specifically included in the project code analysis, the current version of the applicable codes and standards – as of the date of project bid – shall be used.

B. NFPA 70 – National Electric Code.

C. Telecommunications Industry Association (TIA) Standards, current versions in place at the time the project bids are due.

1. 568: Telecommunications Cabling Standards.
2. 569: Telecommunications Pathways and Spaces.
3. 606: Administration Standard for Commercial Telecommunications Infrastructure.
4. 607: Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises.

D. Building Industry Consulting Services International (BiCSi) Telecommunications Distribution Methods Manual (TDMM).

1.6 CONTRACTOR QUALIFICATIONS

A. Contractor shall have necessary certifications to provide for Guarantees as specified herein and within specific Division 27 specification sections.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.8 COORDINATION

A. Coordinate layout and installation of telecommunications pathways with other trades.

1.9 IDENTIFICATION

A. At a minimum, all cables shall be labeled at both ends of the cable.

B. Where cables are too numerous or too small to individually label (e.g. within an enclosure), a diagram must be included to indicate the appropriate far-end destination of each cable.

1.10 SUBMITTALS

A. Product Data:

1. Required for all products identified in the individual specification sections.
2. Product data shall be highlighted or otherwise clearly identified in the submittal.
3. Where a product data sheet includes more than one product being submitted, each product must be identified on the data sheet.
4. Product data submittals that do not meet these criteria will be rejected.

B. Shop Drawings:

1. Samples of system labeling planned for the project including label dimensions, material and lettering examples.

C. Samples: For workstation outlets, jacks, jack assemblies in specified finish, one for each size and outlet configuration, and faceplates for color selection and evaluation of technical features.

D. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector including contractor certification(s) in Installers Program(s) operated by Manufacturer of Cabling, Hardware and/or Accessories to be used.

1.11 DEMOLITION

A. Summary:

1. The drawings are intended to indicate the scope of work required and do not indicate every box, conduit, or wire that must be removed.
2. The Contractor shall visit the site prior to submitting a bid and verify existing conditions.

B. Continuity of Existing Services:

1. No outages shall be permitted on existing systems except at the time and during the interval specified by and coordinated with the owner.
2. All outages must be scheduled when the interruption causes the least interference with normal owner schedules and business routines.
3. No extra costs will be paid to the contractor for such outages which must occur outside of regular weekly working hours.
4. The contractor shall restore any circuit/service interrupted as a result of this work to proper operation as soon as possible.

C. Prior to demolition or alteration of structures, the following shall be accomplished:

1. Survey and record condition of existing facilities to remain in place that may be affected by demolition operations. After demolition operations are completed, survey conditions again and restores existing facilities to their pre-demolition condition.
2. Notify utilities prior to razing operations to permit them to disconnect and remove or relocate equipment that served existing facilities.
3. Existing Communications Systems:

    a. Maintain existing system(s) in service until new system(s) is complete and ready for service.
    b. Disable system(s) only to make switchovers and connections.
    c. Obtain permission no fewer than three working days in advance of proposed interruption of system(s) before partially or completely disabling system(s).
    d. Minimize outage duration.
    e. If required, make temporary connections to maintain service in areas adjacent to work area.
    f. Do not proceed with interruption without owner's written permission.

4. Materials and Equipment:

    a. Materials and equipment for terminating, patching and cross connecting of existing telecommunications and security systems shall be as specified in individual Sections.
    b. Materials and equipment for patching and extending work as specified in the individual Sections.

5. Examination:

    a. Prior to commencing with demolition, a proposed implementation narrative with schedule shall be submitted to the engineer for approval.
    b. The contractor shall provide proof that only qualified personnel with extensive telecommunications experience will perform the demolition.
    c. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on active equipment, use technicians experienced in such operations. Assume all equipment and systems must remain operational unless specifically noted otherwise on drawings.
    d. Whenever possible, the Contractor shall coil existing cable above ceiling for re-termination if cable length will allow. Re-terminated cables shall be tested as specified in the applicable specification section.
    e. Where walls, ceilings, structures, etc., are indicated as being renovated on general drawings, the contractor shall be responsible for the removal of all technology equipment including but not limited to: copper, fiber and coaxial cable, faceplates and jacks, raceways, racking and equipment mounted to the racking, etc., from the renovated area.
    f. Where ceilings, walls, structures, etc., are temporarily removed and replaced by others, the contractor shall be responsible for the removal, storage, and replacement of equipment, devices, fixtures, raceways, wiring, systems, etc.

6. Demolition and Extension of Existing Work:

    a. Demolish and extend existing technology work under provisions of Division 1 specifications and this Section.

b. Some cabling within the ceiling space may serve other building tenants; care shall be exercised to prevent service interrupts.
c. Remove, relocate, and extend existing installations to accommodate new construction.
d. Remove abandoned low voltage cabling and raceway to source of cabling according to the NEC. Refer to the NEC for definition of Abandoned Communications Cabling.
e. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces. Remove all associated clamps, hangers, supports, etc. associated with raceway removal.
f. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is removed. Patch openings created from removal of devices to match surrounding finishes.
g. Disconnect and remove abandoned patch panels, blocks and other distribution equipment.
h. Repair adjacent construction and finishes damaged during demolition and extension work. Patch openings to match existing surrounding finishes.
i. Maintain access to existing technology spaces and equipment that remain active. Modify installation or provide access panels as appropriate.
j. Extend existing installations using materials and methods compatible with existing technology installations, or as specified.
k. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
l. Floor slabs may contain conduit systems. The contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This includes x-ray or similar non-destructive means.
m. The contractor is responsible for all costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

7. Cleaning and Repair:

a. Clean and repair existing materials and equipment that remain or are to be reused.
b. Clean exposed surfaces and check tightness of connections. Re-terminate any loose connections; the contractor shall notify the engineer of any permanently damaged or unusable equipment.
c. Technology items (i.e., patch panels, equipment racks, jacks, faceplates, blocks, cabling, etc.) removed and not relocated remain the property of the owner. The contractor shall be responsible for the disposal of material the owner does not want.

1.12 VIBRATION CONTROLS AND SEISMIC RESTRAINTS

A. Not applicable to this project.

1.13 WORKING CLEARANCES AND ROUTING

A. All minimum clearances for mechanical and electrical equipment shall be maintained.

B. Minimum clearances recommended by the manufacturer shall be observed.

C. The routing of pathways for cabling shall be as indicated on the drawings. Where no pathways are indicated, the contractor shall follow applicable codes and standards and shall use industry best practices.

1.14 MATERIAL HANDLING AND STORAGE

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Prior to installation, the Contractor may, at their discretion and at no additional cost to the Owner, perform tests deemed necessary by the Contractor to confirm product integrity.

1.15 COMMUNICATIONS SYSTEMS DEPLOYMENT CRITERIA

A. The installation, turn-up, configuration and programming of various system components included specified in the Division 27 and Division 28 specifications shall not commence until the following criteria for the rooms and spaces into which they are to be installed are met:

1. Architectural:

a. Walls fully built and painted.
b. Finished floor installed.
c. Finished ceiling installed.
d. Permanent doors installed.
e. Door locks installed:

1) Permanent locks
2) Construction locks
3) Keys held by general contractor and by applicable sub-contractor.

f. The room shall be clean and dust-free. Floors shall be mopped clean and dry.

2. Mechanical / Plumbing / Fire Protection:

a. HVAC units (including pipes, valves, insulation, drip pans, condensate removal, controls) fully installed and turned up.
b. Ducts, dampers and insulation fully installed.
c. All sprinkler piping and heads fully installed and trimmed out.
d. Pre-Action system (if applicable) fully installed and turned up.
e. All M / P / FP systems commissioned, inspected, approved and in operation.

3. Electrical / Technology Systems:

a. All lighting fully installed and operational.
b. All power (including UPS and generator systems) installed and tested and back to Main incoming service source.
c. All raceways and pathways complete with bushings, pull strings and destination identification.
d. All wall, ceiling and floor penetrations properly fire-stopped.
e. All grounding and bonding system components installed and tested.
f. All backbone and horizontal cabling installed, tested and labeled.
g. All electrical systems commissioned, inspected, approved and in operation.

1.16 COMMISSIONING, CONFIGURATION AND PROGRAMMING

A. Refer to individual specification sections.

1.17 WARRANTY

A. Special Warranty for Communications Structured Cabling: Manufacturer's standard form in which manufacturer of Cabling and Termination Hardware agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

B. Unless specifically stated otherwise, all products and systems shall carry a minimum of a one-year material, performance and workmanship warranty. Warranty shall commence when the system as a whole is deemed to be substantially complete by the architect/engineer or the Owner.

1.18 TRAINING

A. Provide training to Owner personnel on operation and maintenance of total system and each component.

B. Training to include:

1. Overview of System Topology and General Concepts
2. Overview of Products Used
3. Overview of Equipment Room Layouts
4. Overview of Labeling Formats
5. Overview of Test Results and their meaning
6. Overview of Documentation

C. Training shall be held at Project Site and shall be conducted during normal working hours.

D. Training session duration shall be not less than four (4) hours.

1. Provide one (1) such sessions.

E. Coordinate with Owner to schedule session(s). Provide adequate notification to allow owner to schedule staff.

F. Provide a video recording of the training in digital format to the owner.

G. Attendance shall be by Owner staff and/or contract maintenance personnel.

1.19 PROJECT CLOSEOUT

A. Refer to individual specification sections.

PART 2 - PRODUCTS

Not Applicable. Refer to individual Division 27 specification sections.

PART 3 - EXECUTION

Not Applicable. Refer to individual Division 27 specification sections.

END OF SECTION 27 05 00

SECTION 27 05 50

COMMON INFRASTRUCTURE FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes items related to all Division 27 and Division 28 infrastructure that are not otherwise specified in an individual specification section.

B. This specification section includes general requirements (part 1), product specifications (part 2) and execution (installation) requirements (part 3) for the following items:

1. Grounding, bonding and surge suppression
2. Pathways
    a. Raceways, boxes and sleeves
    b. Cable trays
    c. Unprotected supporting devices
    d. Firestopping
3. Identification
4. Vibration controls and seismic restraints

C. This specification section is intended to provide minimum product and execution requirements for the above items. Individual Division 27 specification sections may have more stringent requirements specific to the particular section.

1.2 RELATED DOCUMENTS

A. Section 270500 and all related documents therein.

1.3 ABBREVIATIONS AND ACRONYMS

A. The following Abbreviations & Acronyms apply to this document and its companion sections for clarification and direction. Some or all may apply to the project. Refer to project drawings for additional abbreviations and acronyms.

BCT	Bonding Conductor for Telecommunications
EMT	Electrical Metallic Tubing
TGB	Telecommunications Grounding Busbar
TMGB	Telecommunications Main Grounding Busbar
TVSS	Transient Voltage Surge Suppression

1.4 DEFINITIONS

A. The following definitions apply to this document and its companion sections for clarification and direction. Some or all may apply to the project.

Cable Tray	A support mechanism used to route and support telecommunications and other optical fiber cable. Cable trays may be equipped with side walls or barriers to constrain a cable's horizontal placement or movement.

Firestop	A fire-rated material, device, or assembly of parts installed in a penetration in a fire-rated barrier in accordance with a firestop system or engineering judgment to prevent the spread of fire, temperature, and gases of combustion.
Firestopping	The process of installing nationally recognized testing laboratory (NRTL) listed fire-rated materials into penetrations in fire-rated barriers to reestablish the fire-resistance rating of the barrier.
J-Hook	A non-continuous supporting device for horizontal cables that is shaped like a J. It is attached to the building structure using a beam clamp, bracket, or other mounting type devices and either a wire or threaded rod. Horizontal cables are laid in the opening formed by the J to provide support for the cables.
Sleeve	A short length of raceway, usually conduit, for protecting cable passing through a single wall, ceiling, or floor.

1.5 CODES AND STANDARDS REFERENCES

A. Refer to Division 27 specification section 270500.

1.6 CONTRACTOR QUALIFICATIONS

A. Contractor shall have necessary certifications to provide for Guarantees as specified herein.

1.7 QUALITY ASSURANCE

A. Grounding, Bonding and Surge Suppression: Refer to Division 26.

B. Pathways:

1. Raceways, boxes and sleeves: Refer to Division 26.
2. For cable trays, accessories, and components, from manufacturer:

    a. An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
    b. Comply with NEMA VE 1, "Metal Cable Tray Systems," if cable tray types specified are defined in the standard.
    c. Source limitations: Obtain cable trays and components from single manufacturer.

3. Unprotected supporting devices: All devices shall be sourced from a manufacturer engaged in the manufacturing of such devices for a minimum of five years.
4. Firestopping: Refer to Division 07.

C. Identification: Refer to section 270500.

D. Vibration Controls and Seismic Restraints: Not applicable to this project.

E. General:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.8 COORDINATION

A. Grounding, Bonding and Surge Suppression: Refer to Division 26.

B. Pathways:

1. Conduits, boxes and sleeves: Refer to Division 26 specifications.
2. For cable trays, accessories, and components, from manufacturer: Coordinate layout and installation of cable trays and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
3. Unprotected supporting devices: Comply with TIA-569.
4. Firestopping: Refer to Division 07.

C. Identification: Not applicable to this project.

D. Vibration Controls and Seismic Restraints: Not applicable to this project.

1.9 IDENTIFICATION

A. Comply with TIA-606.

1.10 SUBMITTALS

A. Product Data:

1. Grounding, Bonding and Surge Suppression: For each type of product specified and planned for installation in the project.
2. Pathways

    a. Raceways, boxes and sleeves: Refer to Division 26 specifications. Where specialty boxes are called for in this section, include product data for each box type.
    b. Cable trays: Include data indicating dimensions and finishes for each type of cable tray indicated.
    c. Unprotected supporting devices: Include data indicating dimensions and finishes for each type of device planned installation in the project.

3. Firestopping: Refer to Division 07.
4. Identification and labeling: For each identification product indicated.
5. Vibration controls and seismic restraints: Not applicable to this project.

B. Shop Drawings:

1. Grounding, Bonding and Surge Suppression: Refer to Division 26.
2. Pathways

    a. Raceways, boxes and sleeves: Not required.
    b. For each type of cable tray:

        1) Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements.
        2) Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

    c. Firestopping: Refer to Division 07.

3. Identification: Documentation of proposed labeling scheme.
4. Vibration controls and seismic restraints: Not applicable to this project.

PART 2 - PRODUCTS

2.1 GROUNDING, BONDING AND SURGE SUPPRESSION

A. TMGB:

1. Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4" by 4” x 20”, nickel plated. The busbar shall be NRTL listed for use as TMGB.
2. Mounting Hardware: Stand-off brackets that provide a 4” clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600V switchboards, impulse tested at 5000V.

B. TGB:

1. Predrilled rectangular bars of hard-drawn solid copper, 1/4" by 2” x 12”, nickel plated. The busbar shall be NRTL listed for use as TMGB.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm) clearance to access the rear of the busbar. B rackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000-V.

C. BCT and Bonding Jumpers: Refer to Division 26.

D. Connectors: Refer to Division 26.

E. Labeling:

1. Comply with ANSI/TIA-606 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
2. Adhesive film label with clear protective overlay: machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.2 PATHWAYS FOR COMMUNICATIONS SYSTEMS

A. Raceways, Boxes and Sleeves: Refer to Division 26.

1. Raceway size shall follow referenced standards unless noted otherwise.
2. Minimum raceway size for all Division 27 and Division 28 cabling shall be 3/4".

B. Enclosure Heater

1. Operate on 120V
2. Integral or remote air temperature sensing thermostats

    a. Maintain a minimum of temperature of 40 degrees Fahrenheit

3. Basis of design:

    a. Chromalox SL-B
    b. Or approved equal

C. Cable Trays:

1. Basket-type cable tray:

    a. Construction: Carbon steel wire, ASTM A 510, Grade 1008. Wire welded, bent, and surface treated after manufacture.

1) Cable tray shall consist of continuous, rigid, welded steel wire mesh cable management system, to allow continuous ventilation of cables and maximum dissipation of heat, with UL Classified splices where tray acts as Equipment Grounding Conductor (EGC). Wire mesh cable tray will have continuous top side wire to protect cable insulation and installers.
2) Mesh: 2x12 inches or as indicated on drawings
3) Straight Section Lengths: 118 inches.
4) Wire Diameter: Varying wire sizes to meet application load requirements; to optimize tray strength; and to allow tray to remain lightweight.

b. Finish: Hot-Dip Galvanizing After Fabrication: ASTM A 123.
c. Fittings: Wire mesh cable tray fittings are field-fabricated from straight tray sections, in accordance with manufacturer's instructions.
d. Supports:

1) Ceiling-mounted supports: mount to ceiling structure directly or with at a minimum 3/8" threaded rod.

a) Threaded rod protectors.

2) Wall-mounted supports.
3) Underfloor supports: mount directly to floor or to floor posts.

e. Accessories

1) Splices: including those approved for electrical continuity (bonding), as recommended by cable tray manufacturer.
2) Dividers: Not applicable to this project.
3) Additional accessories: as required for a complete cable tray system.

2. Cable runway (a.k.a. 'ladder rack'): Refer to section 271000.
3. Warning signs:

a. Lettering: 1-1/2-inch high, black letters on yellow background.
b. Legend: "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

D. Unprotected Supporting Devices

1. J-Hooks:

a. Device shall have a flared edges and a bearing surface of sufficient width to comply with minimum bend radii of cables as defined in the referenced standards.
b. Device shall have a cable retainer mechanism to contain cables after installation. Retainer shall be operable to add new cables.
c. Device shall have options for mounting to various types of building structures. Refer to Division 26 for hangers and supports.
d. Device shall be manufactured in multiple sizes consistent with standard trade diameters:

1) 1 in.
2) 1-1/4 in.
3) 2 in.
4) 3 in.
5) 4 in.

e. Device shall be electro-galvanized or powder coated finish suitable for indoor locations.

f. Device shall be UL listed.

2. Bridle Rings:

a. Device shall be constructed so as to allow the addition of cables though an open slot in the ring.
b. Device options shall include screw threads for direct attachment to wooden components and machine threads for attachment to other supporting means such as beam clamps. Refer to Division 26 for hangers and supports.
c. Devices shall include a plastic 'saddle' to increase the surface area for cable support.
d. Device shall be manufactured in multiple sizes consistent with standard trade diameters:

1) 1/2 in.
2) 3/4 in.
3) 1 in.
4) 1-1/4 in.
5) 2 in.
6) 4 in.

e. Device shall be electro-galvanized finish suitable for indoor locations.
f. Device shall be UL listed.

3. D-Rings:

a. Device shall be of cast aluminum and constructed so as to allow secure screw attachment to vertical surfaces.
b. Device shall be manufactured in multiple sizes consistent with standard trade diameters:

1) 2 in.
2) 3 in.
3) 4 in.
4) 5 in.

c. Device shall be electro-galvanized finish suitable for indoor locations.

E. Firestopping: Refer to Division 07.

2.3 IDENTIFICATION

A. Comply with TIA-606 and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive, self-laminating, wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process. Adhesive shall be permanent acrylic type. Flag-type marker tapes are not acceptable.

D. Heat-Shrink Type Labels: Non-corrosive plastic labels with circuit identification legend machine printed by thermal transfer or equivalent process, attached to wire through use of non-corrosive, weatherproof heat-shrink tape and a heat gun.

2.4 VIBRATION CONTROLS AND SEISMIC RESTRAINTS

A. Not applicable to this project.

2.5 BACKBOARDS

A. Plywood wall coverings are covered in Architectural specifications sections and/or drawings.

PART 3 - EXECUTION

3.1 GROUNDING, BONDING AND SURGE SUPPRESSION

A. Comply with ANSI/TIA-607.

B. Refer to Division 26 specifications.

C. Secure grounding and bonding conductors at intervals of not more than 24 inches.

D. Install BCTs in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.

3.2 PATHWAYS

A. General: Comply with TIA-569.

B. Raceways, Boxes and Sleeves: Refer to Division 26.

C. Cable Trays:

1. Basket-type cable tray:

a. Load Span Criteria: Install and support cable management system in accordance with IEC 61537, with load span criteria of L/200 and a Safety Factor of 1.7.
b. Fill Ratio: Cable tray may be filled to 40% of total fill capacity. Notify Engineer if size of cable tray indicated on plans will exceed fill ratio for required cable quantity.
c. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
d. Install cable tray level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

1) Center (pendant) supports: Center supports are permitted in cable trays up to 8" in width.
2) Trapeze supports: Required for cable trays greater than 8" in width.
3) Provide 3/8 inch threaded rods for support of 12 inches wide or smaller runway.
4) Provide 1/2 inch threaded rods for support of runway greater than 12 inches in width.
5) Threaded rod protectors: Install protectors to a height of 6" above the top of the cable tray.

e. Install cable tray with a minimum of 8" above and 12" on at least one side to permit access for installing cables.
f. Cutting: Field-fabricated changes in direction & elevation by cutting & bending cable tray:

1) Cut cable tray wires in accordance with manufacturer's instructions.
2) Cable tray wires must be cut with side-action bolt cutters with offset head to ensure integrity of protective galvanic layer.
3) Remove burrs and sharp edges from cable trays.

g. Grounding: Ground cable trays according to manufacturer's written instructions.
h. Protection:

1) Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure cable tray is without damage or deterioration at time of Substantial Completion.
2) Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

i. Cables:

1) Install cables only when each cable tray run has been completed and inspected.
2) Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
3) In existing construction, remove inactive or dead cables from cable trays.
4) Cables by divisions other than 27 or 28 are permitted to be installed in the cable tray provided they are installed win accordance with these specifications. Power cables (NEC Class 1) are not permitted to be run in the cable tray.

2. Cable runway (a.k.a. 'ladder rack'): Refer to section 271000.
3. Warning signs: Install warning signs on cable trays at a maximum separation of every other cable tray section, with no more than 20' between signs.

D. Unprotected Supporting Devices

1. J-Hooks:

a. J-Hooks are to be used for the support of horizontal cable runs.
b. J-Hooks shall be attached to building structure or to individual supports designated for the J-Hooks. J-Hooks shall not be attached to lay-in (suspended) ceiling support wires. Refer to Division 26 for hangers and supports.
c. Maximum cable quantity allowable for J-Hooks shall be 24 cables. Where larger parallel runs of cable exist, additional J-Hooks shall be provided.
d. J-Hook capacity shall not exceed 50% of rated device capacity.
e. Where cable routing changes elevation vertically, install adequate quantities of J-Hooks in inverted positions to maintain minimum bend radius of cables.
f. Where cable routing changes direction horizontally, J-Hook shall be installed such that the longer vertical part of the J-Hook forms the inside of the change in direction.
g. J-Hooks shall be positioned such that cables not resting against the J-Hook retaining clip.

2. Bridle Rings:

a. Bridle rings may be used for the support of vertical cable runs only.
b. Bridle rings shall be attached to building structure or to wood components. Refer to Division 26 for hangers and supports.
c. Maximum cable quantity allowable for bridle rings shall be 12 cables.
d. Bridle ring capacity shall not exceed 50% of rated device capacity.
e. Bridle rings may not be used for cable routes that change direction.

3. D-Rings:

a. D-rings are to be used only for the support of cross-connect wire in the Telecommunications Room.
b. D-rings shall be attached to wood components. Refer to Division 26 for hangers and supports.
c. Maximum cable quantity allowable for D-rings shall be 12 cables.
d. D-ring capacity shall not exceed 50% of rated device capacity.

E. Firestopping: Refer to Division 07.

3.3 IDENTIFICATION

A. Conduit and box identification:

1. Labels shall be white background with black lettering.
2. Lettering size shall be as large as practicable (up to 16-point). No lettering shall be smaller than 12-point.

B. Cable and wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

C. Raceway Identification:

1. Label each raceway with destination description and use.
2. Protect label with clear laminate.

END OF SECTION 27 05 50

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SECTION 27 10 00

COMMUNICATIONS CABLING

PART 1 – GENERAL

1.1. SCOPE OF WORK

A. This section specifies the City of Madison requirements for product design, performance, quality assurance, and contractor responsibilities for the execution of work to install a complete Category 6 (CAT6) structured cabling system.

B. Execution of work includes but is not limited to the delivery and storage of materials, preparation, installation, field testing, and project completion tasks.

C. System certification and warranty requirements for completed work and future moves, adds, and changes (MACs) are also specified in the section.

1.2 RELATED SPECIFICATIONS

A. Section 01 33 23 Submittals.

1.3. CONTRACTOR QUALIFICATIONS

A. The Contractor shall have experience in the installation and testing of similar systems a specified in the plans and specifications for this contract.

1. The Contractor shall have completed at least 2 projects of similar size and scope within the last 24 months.
2. The contractor shall provide references upon request. Information to provide shall include project name, address, date of installation, client name, title, telephone number, and project description.

B. The Contractor shall be certified by the connectivity manufacturer to install, service and warranty the specified product from the time of bidding through the duration of the contract installation and warranty period.

C. The Contractor must maintain a State Contractors License as required by the State of Wisconsin.

D. All members of the Contractors 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 use of tools and equipment required for the complete installation.

E. The Contractor shall own and maintain tools, installation equipment, and testing equipment necessary for the successful installation and testing of Optical and Category 5E, 6, and 6A premise distribution systems.

F. The Owners reserves the right to require the Contractor to remove from the project any such employee the Owner deems to be incompetent, careless, or insubordinate.

1.4. DRAWINGS AND INSPECTION OF THE SITE

A. The Communication (Technical) floor plan drawings are in PDF format, are not typically dimensioned, and should not be scaled. The contractor should refer to the Architectural sheets and construction details for dimensions.

B. The Contractor shall review all site conditions prior to submitting a bid for this project. Any obvious discrepancies between site conditions and the bidding documents shall be brought to the attention of the Architect/Engineer immediately so clarification can be made to the bidding documents by addendum.

C. Any existing wires, utilities, or equipment shown on the drawings as existing are for general information and to the best knowledge of the Architect/Engineer. The contractor shall field verify all existing conditions.

D. The contractor shall field verify distances and equipment placements, and coordinate all installation locations with other trades, construction managers and the general contractor prior to installation.

E. Change order requests for additional material or labor costs due to the contractor's lack of knowledge of existing field conditions will not be allowed.

1.5. SUBMITTALS

A. The Contractor shall review Section 01 33 23 Submittals for additional information.

B. The Contractor shall provide a complete submittal package prior to ordering equipment and materials. Partial submittals will not be considered. A complete submittal shall include but not be limited to the following:

1. Manufacturers data (specifications, "Cut Sheets")
2. Wiring diagrams for all installed cabling
3. Equipment rack and cabinet layouts
4. List of cabling distances (typical and maximum) for all structured cabling

C. The Contractor shall provide all license and certification documents for the project manager and all project technicians as part of the product submittal. All documents shall be valid through the completion of the installation and warranty period. Documents shall include but not be limited to the following:

1. State of Wisconsin Contractors license.
2. Structured cabling and termination equipment installation certifications for:

    a. Copper
    b. Optical Fiber Connectivity
    c. Cabling

D. Product submittals are required for sole source products.

E. Product submittals are not required for Owner provided equipment and materials. However miscellaneous materials required for a complete installation of Owner provided equipment may be necessary.

F. Work shall not proceed until all submittal items have been approved.

1.6. PRODUCT SUBSTITUTIONS

A. The Contractor shall thoroughly review all specifications associated with the Division 27 installations for product specific information.

B. Substitutions for sole sourced products will not be permitted.

C. Substitutions for items to be considered as equals shall be submitted for review at the time of bidding in accordance with the bidding instructions. Approved substitutions will be identified by a written addendum to the bidding documents prior to the end of bidding. Only items in the approved addendum will be allowed as substitutions.

1.7. TESTING

1. Test instruments shall meet or exceed applicable requirements in TIA-568.
2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
3. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Calibrate test unit(s) or have test unit(s) calibrated to factory compliance prior to beginning any cabling test.

   a. Optical Fiber Cable Tests:

      1) Link End-to-End Attenuation Tests:
         a) Single Mode link measurements: Test at 1300 nm in 1 direction according to TIA-526-17, Method A.1, One Reference Jumper.

      2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA-568.

   b. UTP Performance Tests – Backbone Cable:

      1) Test for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors.

   c. UTP Performance Tests:

      1) Test from Horizontal Cross-connect to Tele- communications Outlet.
      2) Confirm all pairs to be free of shorts and opens.
      3) Verify pair validity, polarity, and conductor position on the terminating blocks (Wire Map).
      4) Perform Permanent Link performance tests according to TIA-568 to Category of cabling specified above.

PART 2 - PRODUCTS

2.1. GENERAL

A. This section indicates pre-approved product manufacturers, specific products, or minimum product performances. Substitutions/alternates to this information shall only be allowed as described in paragraph 1.7 above.

B. The manufacturer of the connectivity products specified in this document as required for construction of the cabling infrastructure shall be:

   1. Hubbell Premise Wiring.

C. The manufacturer of the cabling products specified in this document as required for construction of the copper cable infrastructure shall be:

   1. Mohawk Cable.

D. The manufacturer of the fiber optic cabling products specified in this document as required for construction of the fiber optic cable shall be:

   1. Mohawk Cable.
   2. Pre-approved equal.

2.2. 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 un-shielded 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. CAT6 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. CAT6 jacks shall meet or exceed CAT6 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 shall be specified by the Owner.
12. CAT6 modular jacks shall be:

    a. Hubbell:

        1) HXJ6EI (Category 6 – Ivory).

B. Category 6A 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 un-shielded 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. CAT6A jacks shall be backward compatible with existing category 3, 5, 5E and 6 cabling systems for fit, form and function.
8. Jacks shall be manufactured in the USA.
9. CAT6A jacks shall meet or exceed CAT6A transmission requirements for connecting hardware as specified in ANSI/TIA-568-C-2 transmission performance specifications for 4-pair 100 ohm.
10. Jacks shall be UL listed and CSA certified.
11. Colors shall be specified by the Owner.
12. CAT6A modular jacks shall be:

    a. Hubbell:

        1) HJ6AEI (Category 6A – Ivory).

2.3. FACE PLATES

A. All faceplates shall meet the following specifications:

1. Faceplates shall UL listed, CSA certified, and shall be constructed of high impact UL94 V-0 rated thermoplastic.
2. Faceplates shall be compatible with standard NEMA openings and boxes.

    a. Faceplates for single gang boxes shall be 2.75” W x 4.5” H (69.8 mm x 114.3 mm).
    b. Faceplates for double gang boxes shall be 4.5” W x 4.5” H (114.3 mm x 114.3 mm).
    c. Mounting screws shall #6-32 pan head Phillips/slotted and color matched to the faceplate.

3. Port size in each faceplate shall fit the CAT6 modular jack or snap-fit fiber optic, audio, and video modules for multi-media applications.
4. Faceplates shall be rear loading with a designation window.
5. Faceplates shall be provided with clear plastic and color matched label field covers and shall provide ANSI/TIA/EIA-606-A compliant workstation outlet labeling.
6. Work area faceplates shall be:

    a. Hubbell (IFP series):

        1) IFP14EI (4-port Ivory).

2.4. CABLE

A. Category 6 UTP:

1. Plenum cable construction shall be four twisted pairs of 23AWG insulated solid conductors with a ripcord surrounded by a tight outer jacket.
2. Non-plenum cable construction shall be four twisted pairs of 23AWG insulated solid conductors with a ripcord surrounded by a tight outer jacket.
3. No minimum compliant cable will be accepted; this facility requires additional band width.
4. The ripcord shall be directly underneath the outer jacket.
5. Cable shall be marked with the manufacturer and pertinent information. UL, ETL, or CSA agency certification or verification markings shall be on the cable jacket according to the certifying agency's requirements.
6. Color coding of pairs shall be as follows:

    a. Pair 1: white/blue; blue.
    b. Pair 2: white/orange; orange.
    c. Pair 3: white/green; green.
    d. Pair 4: white/brown; brown.

7. Plenum or riser rated jackets.
8. Cable shall be supplied in 1000 foot spools or 1000 foot Reelex boxes.
9. Cable shall exceed CAT6 transmission requirements specified in ANSI/TIA/EIA-568-C-2.
10. Cable shall be UL and C(UL) listed.
11. Cable shall exceed the requirements of TIA/TSB-155, 10 GB/S Ethernet operation over 37 meters channel length.
12. CAT6 UTP horizontal distribution cable as specified in the contract documents shall be

    a. Mohawk Advancenet Cable:

        1) Plenum M57193.
        2) Riser M57202.

B. Category 6A UTP:

1. Plenum cable construction shall be four twisted pairs of 23AWG insulated solid conductors with a ripcord surrounded by a tight outer jacket.
2. Non-plenum cable construction shall be four twisted pairs of 23AWG insulated solid conductors with a ripcord surrounded by a tight outer jacket.
3. No minimum compliant cable will be accepted; this facility requires additional band width.
4. The ripcord shall be directly underneath the outer jacket.
5. Cable shall be marked with the manufacturer and pertinent information. UL, ETL, or CSA agency certification or verification markings shall be on the cable jacket according to the certifying agency's requirements.
6. Color coding of pairs shall be as follows:

    a. Pair 1: white/blue; blue.
    b. Pair 2: white/orange; orange.
    c. Pair 3: white/green; green.
    d. Pair 4: white/brown; brown.

7. Plenum or riser rated jackets.
8. Cable shall be supplied in 1000 foot spools or 1000 foot Reelex boxes.
9. Cable shall exceed CAT6A transmission requirements specified in ANSI/TIA-568-C-2.
10. Cable shall be UL and C(UL) listed.
11. CAT6A UTP horizontal distribution cable as specified in the contract documents shall be

    a. Mohawk GigaLAN 10 Cable:

1) Plenum M58646.
2) Riser M58650.

C. Backbone distribution cable – Fiber Optic:

1. Single-mode fiber backbone distribution cable shall be available with multi-strand construction for intra-building applications.
2. OFNR or OFNP will be determined at each site. The contractor shall be responsible to assure that the proper type of jacketing is being used. Failure to meet local code will cause the replacement of at no expense to the Owner.
3. Single-mode fiber shall be dispersion un-shifted fiber in compliance with ANSI/TIA-492 CAAA.
4. Intra-building fiber distribution cable design shall be according to ANSI/ICEA S-83-596.
5. Single-mode backbone fiber distribution cable, when installed, shall exceed the performance requirements of ANSI/TIA-568-C-3.
6. Single-mode optical fiber distribution cable shall be:

a. Mohawk Cable (basis of design):

1) Single-mode riser M9W042 (12 strand), unless otherwise specified by the Owner.
2) Single-mode plenum M9W048 (12 strand), unless otherwise specified by the Owner.

b. Pre-approved equal.

2.5. 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 single-mode 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-563-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 10GB/S Ethernet performance requirements of IEEE802.3.

H. LC fiber connectors when properly installed onto qualified cable shall exceed the mechanical and environmental performance requirements of ANSI/TIA-568-C-3.

I. Single Mode optical fiber horizontal distribution cable connectors shall be:

1. Hubbell (Prolick):

a. Single-mode LC – FCLC900KSM12.

2. AFL (Fast):

a. Single-mode LC – FAST-LC-SM.

2.6. PATCH PANELS

A. Category 6

a. CAT6 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 gauge steel with rolled edges on top and bottom for proper stiffness.

c. Panels shall accommodate a minimum of 24 ports for each rack mount unit (1 RMU=1.75 inches). 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 connectors

f. Panels shall have individual port identification numbers on the front and rear of the panel. Panels shall have the CAT6 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. CAT6 panels shall be backward compatible with existing category 3, 5, and 5E cabling systems for fit, form, and function.

k. CAT6 patch panels when installed shall exceed the link or channel performance requirements of ANSI/TIA/EIA-568-C.2.

l. CAT6 patch panels shall be able to accommodate 10G in a 37 meter channel per TSB-155.

m. CAT6 patch panels shall be:

1. Hubbell (Nextspeed 6 series)

1. 24 port – P6E24U.
2. 48 port – P6E48U.

B. Category 6A

a. CAT6A 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 gauge steel with rolled edges on top and bottom for proper stiffness.

c. Panels shall accommodate a minimum of 24 ports for each rack mount unit (1 RMU=1.75 inches). 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 connectors

f. Panels shall have individual port identification numbers on the front and rear of the panel. Panels shall have the CAT6A 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. CAT6A panels shall be backward compatible with existing category 3, 5, 5E and 6 cabling systems for fit, form, and function.

k. CAT6A patch panels when installed shall exceed the link or channel performance requirements of ANSI/TIA-568-C.2.

l. CAT6A patch panels shall be:

1. Hubbell (Nextspeed 6A series)

1. 24 port – HP6A24U.
2. 48 port – HP6A48U.

2.7. RACKS – FREE STANDING – 2 POST

A. Rack material shall be structural aluminum with 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 the thread fit.

E. The standard rack height shall be 7 feet (84 inches) and have a capacity of 45RMU.

F. Rack base angles shall be pre-drilled for floor mounting and for assembly to vertical rails.

G. Racks shall accommodate expansion of cable capacity and added volume for CAT6 cabling.

H. Free standing racks and accessories shall be:

1. Hubbell (Nextframe series)

a. HPW84RR19.

I. NOTE: Each basic rack delivered shall consist of equipment rack, isolation pads, 18” wide black ladder rack and mounts to secure to the rack, a vertical electrical 20 amp outlet strip (minimum of 6 receptacles) with mounting brackets.

2.8. CABLE MANAGEMENT – VERTICAL

A. 19” metal panel, size as indicated on the drawings.

B. Distribution rings or ‘fingers’ front and rear, minimum 3.75 inch deep.

C. Pass-through access holes.

D. Baked-polyester powder coat finish; Black.

E. Dual-hinged removable doors, front and rear.

2.9. CABLE MANAGEMENT - HORIZONTAL

A. Full-height high-capacity assembly, width as indicated on the drawings, minimum 6” deep.

B. ‘Fingers’ located on both sides at 1U spacing.

C. Tool-less adjustable spools.

D. Baked-polyester powder coat finish; Black.

E. Dual-hinged removable door.

2.10. INNER - DUCT

A. Fiber optic cable shall be installed with inner-duct for protection of fiber cables in a shared pathway.

B. Inner-duct shall be rated for the plenum or riser environment that it is being installed in.

C. Three inner-ducts shall be run between closets. One for current installation and two spare for future applications.

D. Size: 1” corrugated.

E. Flexible and light weight.

F. Pre-threaded with pull line.

PART 3 - EXECUTION

3.1. DELIVERY, STORAGE, AND HANDLING

A. Materials delivered to the site shall be stored in a clean, dry, and secured area, preferably indoors and shall not interfere with other construction activity.

B. Storage temperature shall adhere to the manufacturers recommendations.

C. Handling of any materials packaged or un-packaged shall be in such a manner as to avoid damage to the item.

D. Installation of category cable shall be within the recommended temperature range specified by the manufacturer. Cable installation temperature shall above 50 f is recommended.

3.2. PREPARATION

A. Cable Pathways and Firestops:

1. Cable pathways including but not limited to conduit, cable trays, ladder racks, raceway, slots, sleeves, etc. shall be located and mounted according to the contract drawings and manufacturers installation instructions. Pathways shall not be installed in wet areas.
2. Cable pathway fill ration, 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 ration in any one 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 the Architect/PE approval.
7. core drilling of holes for fire-rated poke through outlet devices shall have approval of the structural engineer or PE on the contract drawings prior to starting the work.
8. Pathways for vertical cable runs such as slots and sleeves shall be installed in the proper location in accordance to applicable codes and standards.

B. Telecommunication Rooms and Equipment Rooms:

1. Telecommunication Room (TR) layout and location shall be in accordance with the guidelines of ANSI/TIA-569-B. TR's shall not be installed in wet areas, near EMI sources, or caustic chemicals.
2. Layouts of rack, cabinet, or enclosure locations shall be according to the approved submittal drawings.
3. Racks and cabinets shall be secured to the floor suing proper anchors and fasteners.
4. Mount and assemble racks, cabinets, brackets, and enclosures per the manufacturer's installation instructions. Mount patch panels and cable management accessories in the specified sections.
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-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 that permits 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 location in the housing base.
2. Layout 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 the appropriate wall anchors for the wall material being anchored to. Installing mounting screws without using anchors will not be permitted. Mounting to studs is preferred.
4. Mount base plate or surface box or MUTOA to outlet location using the proper fasteners. Note: furniture and wall outlet applications require mounting of the base plate prior to cable pulling and connector termination.
5. Install cover and base plates.
6. Refer to detailed manufacturer's guidelines for cable deployment and termination of jacks into surface housings. Due to the larger size of CAT6 cables proper cable bend radius must be maintained. Certain restrictions may apply when dressing CAT6 cabling in to surface housings.

3.4. INSTALLATION

A. Cable Support:

1. The contractor shall install all supports for cables specified in this section. Traditional ladder rack shall be used in each Telecommunication Room. Basket and J-hooks shall be used for horizontal cable support.
2. Cable supports shall be spaced randomly but no further than 5'-0"apart.
3. Inner-ducts shall be run between each wiring closet or Telecommunications Room. One shall be 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. The Contractor shall provide all incidental cable management products required for a complete and neat cabling installation. Incidental products include but are not limited to sleeves or conduit raceways required to protect exposed cabling.
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 the 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.
7. Conduit is only required if building codes or environmental conditions require it. Rigid or EMT metal conduits are suitable for building installation. Adequate planning should allow for a minimum of 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 the cable manufacturer to get recommendations 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 (2)-90 degree bends install a pull box.

    a. Exceptions to this shall be as follows:

        1) The total run is not longer than 33 feet.
        2) The conduit size is increased to the next trade size larger.
        3) One of the bends is located within 12 inches of the cable feed end (this exception only applies to placing operations where cable is pushed around the first bend).

10. All conduits shall 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 shall not be designed with continuous closed sections longer than 100 feet without pull points or pull boxes installed.
12. All conduits should terminate above on in the installed ladder racks and allow for proper cable racking. Cable materials 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 inches without a bend and at least 8 feet above finished floor. 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 provide the easiest access.
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/exit on the same wall. If this is not possible provide and install ladder rack inside the room for distribution from wall to wall.
18. All floor penetrations shall be core drilled with a maximum of 1/4 inch size greater than the exterior diameter of the riser conduit.
19. Conduits entering through a wall shall be reamed, bushed, and terminated as close as practicable to the terminating rack or wall.
20. Terminations above the suspended ceiling shall terminate no less than 3 inches above the finished ceiling and shall be finished with a bush opening.
21. All conduit shall be labeled at each end of the conduit wwith a uniqe identifier and the destination (far end) of the conduit.

22. All floor penetrations shall be at columns, exterior walls, or in equipment rooms.
23. Cables shall be supported at the height of the bottom flange of structural beams using a rigid support method (I.E. threaded rod, beam clamps, etc.)
24. Do not support cables from duct work, sprinkler piping, water piping, waste/vent piping, conduit, ceiling wire, or other support systems.
25. The conduits or sleeve will be installed per TIA-569-B and shall have all penetrations sealed with an approved fire stop product.
26. Provide independent support systems for each low voltage cabling system.

B. Cable:

1. CAT6 cable will be run for data. CAT6A will be run for all Wireless Access Points and AV locations. CAT6 gel 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 shall utilize T568B wiring. The Contractor shall be responsible for removing/replacing any wiring that is not in compliance with this requirement at no additional cost to the owner.
3. Maximum cable lengths to be 295 feet (90 m) including the service loop. Provide all necessary installation materials, tools, and equipment to perform insulation displacement type terminations at all communications outlets and patch panels.
4. All communication cabling that has become abandoned as part of new renovation, previous renovation, or used as temporary communication cables during the construction process shall be completely removed.
5. Refer to detailed manufacturers guidelines for deployment of Category cable. Certain restrictions apply and specific techniques are recommended.
6. All cabling shall be installed in accordance with the manufacturers written bend radius and pulling tensions. General industry guidelines recommend the following:

    a. Tensile loading of a single 4-pair copper UTP cable shall not exceed 25 LBF
    b. Bend radius of a single 4-pair copper UTP cable shall not exceed 4 times the outside diameter of the cable at a minimum.
    c. Bend radius of multi-pair copper UTP and optical fiber cable shall not exceed 10 times the outside diameter of the cable at a minimum.

7. All conduits and conduit sleeve shall have bushings or grommets installed prior to the installation of communications cables to avoid damage and abrasions to the cable sheathing and insulation.
8. Horizontal cable length for 4-pair copper UTP cables shall not exceed 295 feet. The contractor is responsible for reviewing the plans and specifications prior to bidding and installation and shall notify the Communications Design Engineer of cable runs that may exceed 295 feet.
9. Splices shall not be permitted in any voice or data cable unless otherwise specified or shown on the drawings.
10. Copper cables shall not be placed near sources of extreme heat (I.E. boilers, radiators, heat coils, etc.).
11. Maintain cable twists for all UTP cables. For terminations, cable sheathing shall be stripped back no more than 1/2 inch from the termination point for all Category cables.
12. 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 steel joists.
13. All cables shall be separated and bundled into like groups.
14. 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 foot service loop shall be provided in Telecommunication rooms and shall be installed to allow for future equipment rack/cabinet relocations without the need to re-terminate patch panels. The 10 foot service loop shall be neatly bundled and secured in the ceiling space with large D-rings or placed 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 CAT6 cabling to reduce EMI coupling. Loose random bundling is recommended.
15. Any cabling installed in equipment rooms shall be neatly placed in cabling trays, cabling runways, or horizontal and vertical rack/cabinet cable management devices.

16. Only Velcro straps shall be utilized for cable bundling. Tie wraps, zip ties, and other such rigid devices will not be permitted when bundling cables.
17. Maintain the following separation distances between cables, other system cables, and other building systems:

    a. One (1) foot from fluorescent lights.
    b. One (1) foot from power cables in parallel.
    c. One (1) foot from electrical conduits or other system cables and electrical equipment.
    d. Four (4) feet from motors and transformers.
    e. Three (3) feet from hot water piping and other mechanical equipment.
    f. Ten (10) feet from bus conductors or high current branch circuits.
    g. 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 authorizations by the Communications design Engineer or the Owners Representative.
    h. Communications cabling that must cross power cables or conduit shall cross at a 90 degree angle and shall not make physical contact.

18. Fire seal around all cables running through rated floors and walls. Firestop all cables and pathways that penetrate fire-rated barriers using approved methods, materials and in accordance with all local codes.
19. Contractor shall install a spare pull string with every outlet installed.
20. Do not install cable in wet areas, or in proximity to hot water pipes and boilers.
21. Termination ends of cables 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 contractor shall be responsible for replacing any damaged cables.
22. Backbone cables shall be installed and bundled separately from horizontal distribution cables. Backbone and horizontal cable bundles shall be loose and random.
23. Back bone cables spanning more than three floors shall be supported at the top of the cable run with wire mesh grip and on alternating floors unless otherwise specified by local codes or manufacturers guidelines.
24. Vertical runs of backbone cables entering each Telecommunications Room shall be securely fastened along a properly prepared wall in the room on each floor. Use of cable ladders is preferred.

C. Communications Infrastructure:

1. Maximum cable lengths shall be 295 feet (90 m) including the service loop. Provide all necessary installation materials, tools and equipment.
2. Support and secure cables at patch panel using rear able management bracket, spools or management devise.
3. Cross-connects shall be completed as per the construction schedule.

D. Optical Fiber Cable:

1. Inner-ducts of the proper rating shall be run between each IT Room.
2. Cables for direct burial, aerial, or other outside applications shall be designed specifically for the intended purpose.
3. All optical fiber shall be installed using open cabling methods. Limit cable-bending radius to 20 times the cable diameter during installation and 10 times the cable 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 both ends of each cable as to source and destination. Terminate optical fibers in a consistent and 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. The contractor shall follow all of the connector manufacturer’s recommendations and shall visually inspect all optical fiber connector terminations with a 200 or 400 power microscope for proper termination.

a. An acceptable termination shall show a connector tip that is free of imperfections in 100% of the core and 80% of the cladding.
b. Unacceptable termination flaws shall include but not be limited to; scratches, full or partial cracks, bubbles, pits, epoxy residue, dirt, dust, oil, moisture, grinding, and sanding debris.
c. All unacceptable connectors shall be re-terminated and re-inspected at the contractor's expense.

8. 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.
9. Clean all optical fiber connector tips prior to inserting them into matting receptacles or bulkheads. Install all dust covers.
10. Using approved methods, pull cable into conduit, place into raceway, or place into cable tray as specified. A pull cord (Nylon 1/8" minimum) shall be co-installed with all cable installed in any conduit.
11. Where cables are installed in an air return plenum riser rated cable shall be installed in metallic conduit.
12. Backbone and horizontal cables shall be installed and bundled separately in any pathway.
13. Cables above ceilings or below access floors shall be installed in cable trays or open-top cable hangers.
14. A service coil of at least 3 feet (1 m) is recommended within workstation outlets. At least 6 feet (2 m) is recommended for telecommunication enclosures. Main trunk and OSP cables shall also have a large diameter service coil in the specified location.
15. The recommended maximum spacing of cable supports above the ceiling is 5 feet.
16. 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.
17. 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.
18. 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 of all dust, debris, and other environmental elements during construction until the punch list walkthrough.
2. Each rack or enclosure shall have a dedicated #6 AWG ground wire to a grounding busbar or building ground as defined by the NEC.
3. Secure racks and enclosures to the floor using the manufacturers rack installation kit.

F. Category 6 and 6A Jacks:

1. Refer to specific manufacturer's guidelines for termination of jacks and dressing CAT6 and CAT6A cables inside wall outlets and surface housings. Due to the larger size of CAT6 and CAT6A cable service coils in outlet boxes and surface housings are not recommended.
2. Terminate all jacks according to manufacturer's instructions.
3. All jacks shall be wired using T568B.
4. The contractor shall maintain wiring pair twists as close as possible to the point of termination to assure 10G Base-T performance. 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 (13mm).
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 manufacturers' recommendations for restricted cable bend radius.
8. Cable terminations shall minimize tensile or bending strain on the IDC contacts after assembly of the faceplate or housing to the wall outlet.

G. Category 6 and 6A 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 the manufacturer's installation instructions.

3. To insure proper performance the contractor shall maintain wiring pair twists as close as possible to the point of termination and minimize the length of exposed pairs from the jacket to the IDC 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 a 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 the front of the device. 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 the back side of plate prior to installing to the 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. The contractor shall inspect 100% of all installed connectors 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 busbar (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 of #6 AWG copper wire conductor. A telecommunications grounding busbar (TGB) shall be installed in the Telecommunications Room on each floor, and call be bonded to the TBB. All metal racks, cabinets, pathways, and enclosures shall be bonded to the TGB.
4. Telecommunications equipment shall be grounded according to manufacturer's instructions and in accordance with all 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 protections. Isolation protectors shall be bonded to the TMGB.

3.5. LABELING

A. General:

1. All labels shall be permanent, and machine generated by a labeling machine as follows:

    a. Labels shall be on a permanent polyester material, clear in color.
    b. Lettering shall be black in color.
    c. Hand written labels will not be permitted.

2. The Contractor shall coordinate the labeling scheme with the Owner prior to producing and installing any labels. The Contractor shall provide samples of finished installations at a pre-installation meeting with the Owner prior to completing the installation.
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, schematic designs, and test reports.

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 block.
2. Labels shall have and adhesive backing and shall wrap completely around the circumference of the cable jacket. Label and lettering shall be of an appropriate size with regards to the cable diameter.

C. Equipment Racks, Termination Hardware, and Faceplates:

1. The Contractor shall coordinate the labeling scheme with the Owner prior to producing and installing any labels. The Contractor shall provide samples of finished installations at a pre-installation meeting with the Owner prior to completing the installation.

3.6. TESTING

A. Category 6 and 6A Cable Testing:

1. Permanent link testing shall be completed on all horizontal (station) cables. The Contractor shall be responsible for supplying a channel warranty but the Owner requires that the contractor supplies all the manufacturer's patch cords per the contract.
2. CAT6 and CAT6A 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 cables shall be properly labeled prior to testing. Test results shall be in numerical order by Cable ID.
4. All wiring shall be certified to meet or exceed the specifications as set forth in TIA-568C for specified cable performance requirements for permanent link. All tests shall be performed to 250 Mhz for Category 6 and 500 Mhz for Category 6A.
5. Test results shall include the following information for each pair of each cable installed:

    a. Name of the person performing the test.
    b. Test equipment manufacturer and model number.
    c. Cable ID.
    d. Date of Test
    e. Wire map (pin to pin connectivity and polarity check)
    f. Length (in feet)
    g. Insertion loss
    h. Near end cross talk (Next)
    i. Power sum near end crosstalk (PSNEXT)
    j. Equal level far end crosstalk (ELFEXT)
    k. Power sum equal level far end crosstalk (PSELFEXT)
    l. Return loss
    m. Delay skew

n. Attenuation to crosstalk ratio (ACR)

6. A “PASS” indication shall be obtained for each link using (at minimum) a level III tester that complies with TIA-568-B.2 field test requirements.
7. Correct all malfunctions and “FAIL” when detected and re-test to demonstrate compliance.
8. Record test results for each cable and provide to the General Contractor for the Owners review. All cables shall “PASS” as a condition of installation acceptance.

B. Optical Fiber Testing:

1. Test procedures shall be as described by the following:

a. TIA-568-B Commercial Building Telecommunications Cabling Standard parts 2 and 3.
b. TIA-526-14-A-1998 Optical Power Loss Measurements Of Installed Multi-mode Fiber Cable Plant-OFSTP-14A

2. Pre-installation Testing:

a. Test each conductor of every optical fiber on the reel with a light source and power meter.
b. Obtain the cable manufacturer’s power meter test results for each reel used on the project.
c. Record the readings and the manufacturers reel number and include the information with the as-built documentation.
d. Provide completed forms, optical fiber reel tag IDs and cable manufacturer’s test results to the Owner prior to installing cable.

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 the length of individual fiber strand with a connector terminated on each end.
b. Tier 1 testing for each installed single-mode link shall be performed as an optical power insertion loss measurement as defined by ANSI/TIA-526-7. Testing for single-mode shall be at 1310 and 1550 nanometers. Total link insertion loss (DB) shall be within the specified link loss budget.
c. Tier 2 testing, if required, for each installed single-mode or multi-mode link shall be performed as an OTDR measurement as defined in TIA-TSB-140. The Owner requires Tier 2 testing on all fibers installed in this facility for future troubleshooting.
d. Multi-mode 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 850 and 1300 nanometer windows in both directions. The test setup and performance shall be in accordance with ANSI/TIA-526-14-B, Method B.
e. A reference power measurement shall be obtained by connecting on 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.
f. Readings must not be higher than the “Optimal Attenuation Loss” (OAL). The OAL shall be calculated using the manufacturer’s factory certified specifications 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 Contractor shall use the OAL for comparison with the end to end power loss test results prior to acceptance.
g. Test results must be completed and turned over to the General contractor and the Owner prior to the contract punch list date. Specific due dates will be determined by the General Contractor.

3.6. CONTRACT CLOSEOUT REQUIREMENTS

A. Closeout Documentation: The Contractor shall assemble all closeout documentation required below and provide it digitally in a PDF, searchable (when applicable), format on a compact disc, thumb drive or other compatible digital

device unless otherwise specified below. This documentation shall be kept separate from other similarly required documents and provided to the City of Madison Information Technology representative for review and approval. The documentation shall be provided and indexed as follows:

1. Index of contents.
2. Pre-installation test results, one complete set in approved format indicating all pre-installation tests met or exceeded the specification.
3. Post-installation test results, one complete set in approved format showing all post installation terminations met or exceeded the specification.
4. As-Builts:

    a. The Contractor shall maintain through the construction process a paper set of as-built documentation. Upon completion of the installation and verification by the Owner and Design Engineer that all documentation is complete the contractor shall provide the Design Engineer with the paper plans for inclusion into a digital as-built design set.
    b. Complete floor plan as-builts shall indicate all of the following information:

        1) Include detailed information of cable and pathway layouts, locations of pull points/boxes, and other such products and equipment installed.
        2) Locate all work station outlets, camera, locations and other such data drops; provide the correct alpha numeric cable assigned to each location.
        3) Where product/equipment locations are dimensionally located provide the installed dimensions by either circling the design dimension if correct or providing the field correct dimension. Provide all dimensions for installations not originally dimensioned in the design.
        4) Any deviation in location of an installation shall be noted on the drawings regardless of the reason for change. Items grossly not installed in their intended location shall be "X" out and drawn in the installed location
        5) Indicate all items added or deleted to the contract through change order or other such means. Provide the document number that caused the change.

    c. Provide complete details of final installation of all racks and equipment. Provide the alpha-numeric numbers (range low to high) assigned to each piece of equipment in each rack.

5. Operation and Maintenance information, all of the following items shall be grouped by like item for a specific product or piece of equipment.

    a. A complete set of all submittals.
    b. A complete set of all installation instructions for products and equipment installed. Only one (1) copy of each product or piece of equipment needs to be supplied.
    c. A complete set of all operation instructions for products and equipment installed.
    d. A complete set of all maintenance/care instructions for products and equipment installed.

6. Warranty/guarantee Information:

    a. Provide signed contractors warranty letter for installation and service for the period of one (1) year.
    b. Provide manufacturer's warranty/guarantee information for all products and equipment installed. Verify with all plans and specifications the required terms of warranties/guarantees. If none are specified provide the default manufacturer's warranty/guarantee.

B. Owner Training: The Contractor shall provide Owner Training as needed on all Division 27 installations. The contractor shall verify with the City of Madison Information Technology representative as to what items will be trained, how much training will be necessary and coordinate training dates and times.

END OF SECTION 27 10 00

SECTION 27 20 00

DATA COMMUNICATIONS ACTIVE EQUIPMENT

PART 1 – GENERAL

1.1. SCOPE OF WORK

A. This section specifies the City of Madison requirements for product design, performance, quality assurance, and contractor responsibilities for the execution of work to provide and install the products that provide digital data communications for the project.

B. Execution of work includes but is not limited to the delivery and storage of materials, preparation, installation, field testing, and project completion tasks.

C. System certification and warranty requirements for completed work and future moves, adds, and changes (MACs) are also specified in the section.

1.2 RELATED SPECIFICATIONS

A. Section 01 33 23 Submittals.

1.3. CONTRACTOR QUALIFICATIONS

A. The Contractor shall have experience in the installation and testing of similar systems a specified in the plans and specifications for this contract.

1. The Contractor shall have completed at least 2 projects of similar size and scope within the last 24 months.
2. The contractor shall provide references upon request. Information to provide shall include project name, address, date of installation, client name, title, telephone number, and project description.

B. The Contractor shall be certified by the connectivity manufacturer to install, service and warranty the specified product from the time of bidding through the duration of the contract installation and warranty period.

C. The Contractor must maintain a State Contractors License as required by the State of Wisconsin.

D. All members of the Contractors 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 use of tools and equipment required for the complete installation.

E. The Owners reserves the right to require the Contractor to remove from the project any such employee the Owner deems to be incompetent, careless, or insubordinate.

1.4. DRAWINGS AND INSPECTION OF THE SITE

A. The Communication (Technical) floor plan drawings are in PDF format, are not typically dimensioned, and should not be scaled. The contractor should refer to the Architectural sheets and construction details for dimensions.

B. The Contractor shall review all site conditions prior to submitting a bid for this project. Any obvious discrepancies between site conditions and the bidding documents shall be brought to the attention of the Architect/Engineer immediately so clarification can be made to the bidding documents by addendum.

C. Any existing wires, utilities, or equipment shown on the drawings as existing are for general information and to the best knowledge of the Architect/Engineer. The contractor shall field verify all existing conditions.

D. The contractor shall field verify distances and equipment placements, and coordinate all installation locations with other trades, construction managers and the general contractor prior to installation.

E. Change order requests for additional material or labor costs due to the contractor's lack of knowledge of existing field conditions will not be allowed.

1.5. SUBMITTALS

A. The Contractor shall review Section 01 33 23 Submittals for additional information.

B. The Contractor shall provide a complete submittal package prior to ordering equipment and materials. Partial submittals will not be considered. A complete submittal shall include but not be limited to the following:

1. Manufacturers data (specifications, "Cut Sheets")
2. Equipment rack and cabinet layouts

C. The Contractor shall provide all license and certification documents for the project manager and all project technicians as part of the product submittal. All documents shall be valid through the completion of the installation and warranty period. Documents shall include but not be limited to the following:

1. State of Wisconsin Contractors license.

D. Product submittals are required for sole source products.

E. Product submittals are not required for Owner provided equipment and materials. However miscellaneous materials required for a complete installation of Owner provided equipment may be necessary.

F. Work shall not proceed until all submittal items have been approved.

1.6. PRODUCT SUBSTITUTIONS

A. The Contractor shall thoroughly review all specifications associated with the Division 27 installations for product specific information.

B. Substitutions for sole sourced products will not be permitted.

C. Substitutions for items to be considered as equals shall be submitted for review at the time of bidding in accordance with the bidding instructions. Approved substitutions will be identified by a written addendum to the bidding documents prior to the end of bidding. Only items in the approved addendum will be allowed as substitutions.

PART 2 - PRODUCTS

2.1. GENERAL

A. This section indicates pre-approved product manufacturers, specific products, or minimum product performances. Substitutions/alternates to this information shall only be allowed as described in paragraph 1.7 above.

2.2. MEDIA CONVERTERS

A. All media converters shall meet the following criteria:

1. 10/100/1000BASE-T copper to 1000BASE-X fiber
2. Supports IEEE 802.3af PoE on one or two RJ-45 copper ports
3. Operating temperature range of -40º to 75ºC
4. 4 Port Device:

a. (2) SFP (Small form pluggable) ports with two duplex LC single mode adaptors
a. (2) RJ45 UTP PoE Ports

5. Basis of Design:

a. Omnitron:

1) 9419-1-2-1Z

PART 3 - EXECUTION

3.1. DELIVERY, STORAGE, AND HANDLING

A. Materials delivered to the site shall be stored in a clean, dry, and secured area, preferably indoors and shall not interfere with other construction activity.

B. Storage temperature shall adhere to the manufacturer's recommendations.

C. Handling of any materials packaged or un-packaged shall be in such a manner as to avoid damage to the item.

3.2. INSTALLATION

A. Install as indicated on project drawings.

B. Connect and configure media converters to assure full-speed communications are active on all individual channels.

3.6. CONTRACT CLOSEOUT REQUIREMENTS

A. Closeout Documentation: The Contractor shall assemble all closeout documentation required below and provide it digitally in a PDF, searchable (when applicable), format on a compact disc, thumb drive or other compatible digital device unless otherwise specified below. This documentation shall be kept separate from other similarly required documents and provided to the City of Madison Information Technology representative for review and approval. The documentation shall be provided and indexed as follows:

1. Index of contents.
2. As-Builts:

a. The Contractor shall maintain through the construction process a paper set of as-built documentation. Upon completion of the installation and verification by the Owner and Design Engineer that all documentation is complete the contractor shall provide the Design Engineer with the paper plans for inclusion into a digital as-built design set.
b. Complete floor plan as-builts shall indicate all of the following information:

1) Where product/equipment locations are dimensionally located provide the installed dimensions by either circling the design dimension if correct or providing the field correct dimension. Provide all dimensions for installations not originally dimensioned in the design.
4) Any deviation in location of an installation shall be noted on the drawings regardless of the reason for change. Items grossly not installed in their intended location shall be "X" out and drawn in the installed location
5) Indicate all items added or deleted to the contract through change order or other such means. Provide the document number that caused the change.

c. Provide complete details of final installation of all racks and equipment. Provide the alpha-numeric numbers (range low to high) assigned to each piece of equipment in each rack.

5. Operation and Maintenance information, all of the following items shall be grouped by like item for a specific product or piece of equipment.

    a. A complete set of all submittals.
    b. A complete set of all installation instructions for products and equipment installed. Only one (1) copy of each product or piece of equipment needs to be supplied.
    c. A complete set of all operation instructions for products and equipment installed.
    d. A complete set of all maintenance/care instructions for products and equipment installed.

6. Warranty/guarantee Information:

    a. Provide signed contractors warranty letter for installation and service for the period of one (1) year.
    b. Provide manufacturer's warranty/guarantee information for all products and equipment installed. Verify with all plans and specifications the required terms of warranties/guarantees. If none are specified provide the default manufacturer's warranty/guarantee.

B. Owner Training: The Contractor shall provide Owner Training as needed on all Division 27 installations. The contractor shall verify with the City of Madison Information Technology representative as to what items will be trained, how much training will be necessary and coordinate training dates and times.

END OF SECTION 27 20 00

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 his/her 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

SECTION 27 32 43
RADIO COMMUNICATIONS EQUIPMENT

PART 1 – GENERAL

1.1. SUMMARY

A. This specification describes the materials, equipment and installation requirements required for a complete Radio Communication Equipment installation to be utilized by the City of Madison Fire Department (Owner).

B. The Contractor shall be solely responsible for all of the following:
   1. Ensuring the completed installation meets all applicable codes and regulatory requirements.
   2. Providing all miscellaneous equipment and materials required to complete the installation of equipment and materials described in this specification.
   3. Providing all tools, equipment, and testing devices required to complete the installation.

C. The Contractor shall attend all pre-installation meetings and coordinate with other trades prior to installing materials and equipment. The Contractor shall be solely responsible for any completed work by others that needs to be redone because pre-installation coordination was not completed.

D. Radio receivers and transmitters are not a part of this contract and shall be installed by the City Radio Shop after final acceptance and testing. The Contractor shall be responsible for verifying all final connections with Owner provided equipment prior to completing the installation.

1.2. RELATED SPECIFICATIONS

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of all Radio Communication Equipment. This includes but is not limited to the following:
   1. 01 31 23 Project Management Web Site
   2. 01 33 23 Submittals
   3. 26 xx xx Division 26 specifications as needed

1.3. CONTRACTORS QUALIFICATIONS

A. The Contractor shall be licensed and/or certified for this installation as required by any regulatory requirements.

1.4. SUBMITTALS

A. Submittals are required for all equipment and materials specified within this specification. This shall include but not be limited to antennas, cables, connectors, PolyPhaser, and other components required for a complete radio communication installation.

B. Submittals are required for all mounting hardware required to install equipment specified in this section. Mounting hardware shall include but not be limited to antenna mounts, weatherproof cable boxes and other similar equipment/hardware.

C. Submittal shall include copies of all currently licensed installers

D. In the event a single source product is obsolete or the manufacturer's specifications have significantly changed the Communications Contractor shall submit an RFI through the General Contractor for direction from the Owner. The contractor shall not proceed with submittals until all RFI issues have been resolved.

1.5. 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 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.

1.6. PRODUCT SUBSTITUTIONS

A. The Contractor shall thoroughly review all product specifications associated with this specification.

B. Substitutions for sole sourced products will not be permitted.

C. Substitutions for items to be considered as equals shall be submitted for review at the time of bidding in accordance with the bidding instructions. Approved substitutions will be identified by a written addendum to the bidding documents prior to the end of bidding. Only items in the approved addendum will be allowed as substitutions.

PART 2 - PRODUCTS

2.1. 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.

2.2. ANTENNAS

A. The Contractor shall provide and install the antennas as specified in the table below, alternates shall not be considered. Antennas shall be provided and installed in the quantities and locations indicated in the plans, details, and specifications.

1. Future antenna information is provided for informational purposes only, to assist in locating antenna cables, mounting devices, and installation spacing of antennas.

Manufacturer	**Laird Technologies**	**Laird Technologies**	**Panorama Antennas Ltd.**	**Amphenol**
Model	**Y4503**	**S8060B**	**BS-IN1766**	**BCD-7504-EDIN-0**
Band Type	UHF		VHF	
Alpha Frequency	450-470 MHz	800-900 MHz	139-168 MHz	800 MHz
Horizontal Beam Width			360^{o}	360^{o}
Max Power Input	300W		100W	500W
Polarization				Vertical
Lightning Protection				DC Ground

Manufacturer	Laird Technologies	Laird Technologies	Panorama Antennas Ltd.	Amphenol
Model	**Y4503**	**S8060B**	**BS-IN1766**	**BCD-7504-EDIN-0**
Vertical Tilt				0º
Gain	7.1	0 dBD	0 dB	5.6dBi
Frequency (bandwidth)		62 MHz		
VSWR		1.5:1		≤1.5:1
Connector	N (Female)	N (Female)	N (Female)	
Wind Survival w/o Ice		125 mph		125 mph
Vertical Beam Width			100º	28º
Diameter				3.5 in.
Length		17.5 in.	2.2 ft.	35.2 in.
Weight		0.56 lbs	1.54 lbs	10 lbs
Color		n/a	n/a	n/a
Pigtail		17 cm		
Element Material		Plated Copper Laminate		
Enclosure Material		Fiberglass		
Mounting Style		Tube End		
Mfr Warranty			1 year	
Antenna No.s	1	2-4 & 9-11	5-8	Future 12-14
Cable type	See 1/2 Heliax below	See 1/2 Heliax below	See LMR below	See 7/8 Cellflex below

2.3. ANTENNA CABLE

A. The Contractor shall provide and install the antenna cables as specified in the table below including the antenna cable for the future antennas noted in the table above. Alternates shall not be considered. Antennas shall be provided and installed in the quantities and locations indicated in the plans, details, and specifications.

Manufacturer	CommScope	CommScope	Times Microwave	CommScope
Model	**LDF4-50A**	**LDF4-50A**	**LMR-400**	**AVA5-50FX**
Size/Type	1/2" Foam Heliax Cable	1/2" Foam Heliax Cable	3/8" LMR Coaxial Cable	7/8" Heliax-Coaxial Cable
	50 Ohm Coaxial	50 Ohm Coaxial	50 Ohm Coaxial	50 Ohm Coaxial
Outer Conductor	Annular Corrugated Copper	Annular Corrugated Copper	Stranded	Corrugated Copper
Inner Conductor	Copper Clad Aluminum	Copper Clad Aluminum	Bare Copper	Copper
Max. Frequency Capacity	8.8 GHz	8.8 GHz		
Min. Bending Radius	5 in.	5 in.	1 in.	
Antenna No.s	1	2-4 & 9-11	5-8	Future 12-14

2.4. RADIO EQUIPMENT

A. Radio equipment (transmitters and receivers) will be provided and installed by the CoM Radio Shop after the Radio Communication installation has been completed, tested, and accepted per this specification.

B. Test radios shall be provided by CoM Radio Shop for the final testing of the completed installation, see item 3.6. below.

2.5. POLYPHASER

A. Provide and install one (1) PolyPhaser for each roof mounted antenna.

B. PolyPhaser shall be flange mount 125-1000MHz, maximum surge of 50,000 amp, 600 VDC turn-on, with type N female connector on equipment side and type N male connector on the antenna port.

1. Tessco model IS-50NX-C2-MA

C. Each PolyPhaser shall be installed on the antenna cables within the first 24" of cable as it exits the conduit coming from the roof into the Radio Room (235).

D. Each PolyPhaser shall be grounded to the grounding bar in the Radio Room.

2.6. WALL MOUNTED RACK

A. The Contractor shall provide and install a wall mounted data rack in A/V Equipment Room (266) for the distribution of antenna cabling to various seating arrangements within Parkinson Hall (254).

B. Rack shall be sized to accommodate a minimum of six (6) RF Rack Panels as described below.

2.7. RF RACK PANELS

A. Provide RF Rack Panels as per the antenna riser diagram in the wall mounted rack described above for the distribution of antenna cabling within Parkinson Hall (254).

B. All connections shall be type "N" female connections; panel shall fit standard 19" rack mounting specifications; provide cut sheets with submittal package. Finish shall be black powder coat with white text. Verify quantity, location, and cabling requirements with plans and details for Parkinson Hall.

2.8. MISCELLANEOUS EQUIPMENT

A. The Contractor shall provide and install in quantities as required for a complete installation the following miscellaneous equipment:

1. Any miscellaneous equipment or device required to provide a complete and fully operational installation that meets the requirements of the plans and specifications.
2. Connectors; all connectors shall be high quality type "N" connectors; provide cut sheets with submittal package.

PART 3 - EXECUTION

3.1. COOPERATION OF THE 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 and conduit locations 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 the City Radio Shop for all information necessary to complete the installation and integration with the Owners existing hardware and software.

C. The Contractor shall verify with the Owners Representative from the City Radio Shop 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 Architect and Building Owner for access to non-contract spaces and for coordinating the mounting of any conduit, hangers, etc. in non-contract spaces.

3.2. EQUIPMENT INSTALLATION - GENERAL

A. All antennas and equipment shall be properly grounded as per the plans, details, manufacturer's installation requirements, and code requirements.

B. All mounting hardware (u-bolts, cable clamps, etc) in exterior type environments shall be hot dip galvanized.

3.3. ANTENNA INSTALLATION

A. The Contractor shall review the enlarged plans and details provided in the drawing set indicating antenna locations on the roof and other installation details.

B. All antennas shall be installed per the numbers on the plan which are cross-referenced to the antenna numbers provided in Section 2.2 above.

C. Antennas shall be bolted to the 2" antenna mast pipes with one or two antenna clamps as per the antenna manufacturer's written instructions.

D. The Contractor shall be responsible for all mounting hardware and equipment required for a complete installation except when noted as provided by others in plans and details.

3.4. ANTENNA CABLE INSTALLATION

A. The Contractor shall properly install all antenna cables in conduits and other cable management devices as indicated in the plans and details. This shall include but not be limited to any grounding, fasteners, pull boxes, or other required materials necessary for a complete installation.

B. The following antenna cable installation requirements shall apply to the installation of all antenna cables:

1. All exterior antenna cables shall be clamped to the existing cable clamp channel located on the roof as per details. The Contractor shall provide cable clamps of the appropriate size and spacing as needed for a neat and secure installation of all antenna cables.
2. Strain relief devices shall be used at a minimum spacing of 200 feet during antenna cable installation. Strain relief devices shall remain in place to support the cables after installation. A support cable shall be used between the grips to prevent damage to the cable caused by lifting from only one point.
3. All exterior cables shall have a slight upward incline prior to entering the building to minimize moisture from entering the building.
4. All cables shall enter/leave conduits through the use of entry port boots of appropriate sizes and configurations. This applies to all interior and exterior locations.
5. Cables from the roof down to the Radio Room shall be located in existing vertical conduits. The Contractor shall be solely responsible for ensuring the conduit capacities are not exceeded.
6. All exterior antenna cables shall be continuous (no splices) from the roof antenna to the PolyPhaser connection in the Radio Room (235). Provide sufficient cable as needed for bends and drip loops.
7. Provide/install the PolyPhaser in the Radio Room for lightning protection on each antenna cable installed. Each PolyPhaser shall be properly attached to the antenna cable and the grounding bar located in the Radio Room.
8. All interior antenna cables shall be continuous (no splices) from the PolyPhaser to its final end point except were designated in the plans or details to be broken for installing specific pieces of equipment. Provide sufficient cable as needed for bends and connections.
9. Provide five (5) feet of additional cable fastened to the structure as necessary at the base of the antenna. Provide sufficient cable as needed for bends, and drip loops.
10. The contractor shall use Velcro straps when bundling antenna cables on the interior of the building. The use of zip ties or other plastic fasteners shall not be allowed.

C. Antenna cables shall be run as follows:

1. Antenna 1
   a. Connect 1/2” Heliax cable to Antenna 1 on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to Telecom Room M111.
   c. Provide and install appropriate connectors and make final connection as the primary radio system to be installed with the Station Alerting equipment.
2. Antenna 2
   a. Connect 1/2” Heliax cable to Antenna 2 on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to Telecom Room M111.
   c. Provide and install appropriate connectors and make final connection as the backup radio system to be installed with the Station Alerting equipment.
3. Antennas 3 and 4
   a. Connect 1/2” Heliax cable to each antenna (3 & 4) on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to A/V Equipment Room (266).
   c. Provide and install appropriate connectors and make final connection to the RF Rack Panel.
4. Antennas 5 through 8
   a. Connect LMR-400 cable to each antenna (5 – 8) on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to A/V Equipment Room (266).
   c. Provide and install appropriate connectors and make final connection to the RF Rack Panel.
5. Antennas 9 through 11
   a. Connect 1/2” Heliax cable to each antenna (9 – 11) on the roof
   b. Route cable to the Radio Room, install PolyPhaser, route cable to A/V Equipment Room (266).
   c. Provide and install appropriate connectors and make final connection to the RF Rack Panel.
6. Antennas 12 through 14 (future antennas)
   a. Provide sufficient 7/8” Heliax cable to each future antenna (12-14) location on the roof including the required additional five (5) feet and as needed for bends and drip loops. Fasten all cable to the structure as required. No additional connections at the roof are required.
   b. Route cable to the Radio Room, provide five (5) feet of cable after exiting the conduit from the roof. Antenna cables shall be neatly bundled and fastened to the wall, no additional terminations, PolyPhasers or other connections shall be required.
7. A/V Equipment Room (266)
   a. Provide nine (9) – three foot (3’) jumpers of 1/2” Heliax cable/LMR-400 cable
   b. Provide and install the appropriate connectors to each end of each jumper
   c. Connect one end of each jumper to the RF Rack Panel terminating antennas 3-11

d. Do not permanently connect the other end of the jumper to other RF Rack Panels except to perform testing procedures.

8. Parkinson Hall (Room 254)
   a. Provide twenty three (23) – thirty foot (30') leads of 1/2" Heliax cable/LMR-400 cable
   b. Provide and install the appropriate connectors to each end of each lead
   c. Connect one end of each lead to the RF Rack Panel
   d. Route each lead to the appropriate desk location in Parkinson Hall.

3.5. EQUIPMENT IDENTIFICATION AND LABELING

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 all equipment with the City Radio Shop prior to ordering any labels or tags.

B. Antennas shall be labeled with their assigned antenna number, antenna type, and use.

C. Antenna cable conduits shall be labeled as follows:
   1. Vertical conduits from the roof shall be labeled with the antennas served at the roof level and in the radio room.
   2. Horizontal conduits shall be labeled with the antennas served at both ends.

D. Antenna cables not in conduit shall be labeled as follows:
   1. Individual antenna cables shall be labeled with antenna served when leaving the conduit and at end connector.

E. The RF Rack Panels in A/V Equipment Room (266) shall be labeled as follows:
   1. Each connector on the two (2) panels receiving original antenna cables shall be labeled with the antenna number and antenna type
   2. Each connector on the four (4) panels connecting leads to desk locations in Parkinson Hall shall be numbered with "D-#" where # shall be 1-18, or 32-36.
   3. The jumpers do not need to be labeled

3.6. INSTALLATION TESTING AND ACCEPTANCE

A. The Contractor shall be responsible for pre-testing and troubleshooting the completed radio communication installation for connectivity and grounding requirements. The contractor shall correct all deficiencies prior to scheduling final testing with the City Radio Shop.

B. The City Radio Shop shall perform final testing with the Contractor using appropriate testing equipment and radios as follows:
   1. Visually inspect the entire radio equipment installation against plans and specifications
   2. Visually inspect and test connections for connectivity and grounding.
   3. Connect radios in Parkinson Hall and test for proper signal input/output at each location.
   4. Connect radio to Station Alerting equipment to verify primary and backup radio input/output is working.
   5. Using a hand held radio provide the following tests and reports of the Bi-Directional Amplifier System provided by the Building Owner:
      a. The interior 2nd Floor Admin area for input/output.
      b. The interior Parking Garage BDA loop for input/output.
      c. The interior Command Vehicle Garage BDA loop for input/output.
      d. Provide the City Project Manager and Project Architect a list of all locations having insufficient input/output.
         i. Building Owner shall have additional amplifier antennas installed as needed.
         ii. Retest item 5 as necessary until all areas have acceptable input/output levels.

      Special Note: Item 5 is not a condition of installation acceptance.

C. A completed and accepted installation shall pass all of the above tests (except Item 3.6.B.5 above) for the entire completed installation.

D. 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.

3.7. PRODUCT AND INSTALLATION LICENSING

A. The Contractor shall provide any licensing applications associated with this installation directly to the City Radio Shop. The City Radio Shop will be responsible for all regulatory licensing applications and processing.

END OF SECTION

SECTION 27 35 00
CALL MANAGEMENT (STATION ALERTING SYSTEM)

PART 1 – GENERAL

1.1. SUMMARY

A. All fire stations within the City of Madison Fire Department utilize a digital Station Alerting System (SAS) that provides visual and audio output information specific to the 911 emergency that the unit is being dispatched to. Each fire station has its own control station programmed to announce calls specific to that station.

B. The City of Madison Fire Department has standardized its SAS on designs and equipment by US Digital Designs, Tempe AZ (USDD).

1. All USDD plans, specifications and installation requirements are being provided as part of this contract.

1.2. REFERENCES

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of the SAS. This includes but is not limited to:

1. 01 31 23 Project Management Web Site
2. 01 33 23 Submittals
3. 27 00 05 Communications Cable and Equipment

B. The following references supplied by US Digital Designs are a part of this specification and are to be considered pat of the contract documents.

1. USDD.MWI.ADMIN.2014.06.06.pdf = Fire Admin plan sheets 1-3 as part of the plan set
2. USDD.MWI.FS1.2014.07.31.pdf = Fire Station 1 plan sheets 1-4 as part of the plan set
3. MWI003-QV1-AdminFS01CONTRACTORquote(11AUG2014).pdf = parts list and contractor quote
   a. Bidding contractors shall note this quote sheet is pre-filled out for all bidding contractors and indicates the parts list and components being supplied by USDD only.
   b. contractors not currently trained/certified by USDD shall be required to add the fees as designated on line #46 of M10003-QV1 Quote for each station. See section 1.3 below for more details.
4. Madison End User's Acknowledgement and Agreement (TBD).pdf = sample to be executed upon contractor certification prior to installation
5. USDD Non-governmental FSA System Purchase Contract (MadisonContractor11AUG2014TBD).pdf = sample to be executed upon contractor certification prior to installation
6. USDD Service Agreement (MadisonTBD).pdf = sample to be executed upon contractor certification prior to installation
7. USDD Warranty (Madison).pdf = New System Warranty

1.3. CONTRACTOR REQUIREMENTS

A. The Contractor shall be trained and certified by USDD prior to installing any USDD system components in order to comply with USDD Warranty and Support requirements.

B. Contractor shall be a certified low-voltage system installer.

Contractor shall have applicable state licenses, current, through the end of the warranty period.

1. USDD will perform on site G2 System Training and Certification with a USDD Field Services Manager prior to beginning training.
    a. Bidding contractors who are not pre-certified shall include the costs for certification training in their bid items as designated on line #46 of M10003-QV1 Quote for each station.

1.4. SUBMITTALS

A. The Contractor shall provide only equipment submittals not being supplied directly by the product manufacturer of the Station Alerting System.

B. The Contractor shall verify prior to placing the final order that all equipment to be provided by the product manufacturer is the same as indicated in the plan set. Any discrepancies shall be brought to the Owners attention immediately for clarifications.

C. The Contractor shall provide a copy of the USDD Training and Certification documents prior to being allowed on site and proceeding with the installation of the SAS equipment.

1.5. WARRANTY

A. The USDD system equipment shall be warranted for eighteen (18) months after the date of execution for items 1.2.B.5 and 1.2.B.6 above.

B. The system installation shall be warranted by the Contractor for one (1) year after the accepted date of the general contract. The contractor shall provide this warranty on company letterhead signed by an official of the company.

C. Non USDD parts and equipment shall be warranted for the standard manufacturer's warranty period and shall be provided to the Owner with all other SAS Owner & Maintenance Manuals.

PART 2 - PRODUCTS

2.1. STATION ALERTING SYSTEM

A. The City of Madison Fire Department has standardized on station alerting equipment provided by US Digital Designs, Inc. (USDD). No alternates for this equipment will be allowed.

US Digital Designs, Inc
1835 East Sixth Street Suite 27
Tempe, AZ 85281
Phone (602) 687-1730
Toll Free 877-551-8733

B. All USDD equipment shall be provided as per the plans and equipment lists provided with the USDD bid set documents. This shall only include wiring/cabling between transformers and speakers as indicated on the plans. All other wiring/cabling shall be CAT5 or CAT6 provided by the contractor as per specification 27 00 05 Communication Cable and Equipment.

2.2. CABLING AND WIRING

A. The Contractor shall provide and install all CAT5 or CAT6 cabling between the Station Controller rack and other USDD equipment except as noted in item 2.1.B above. The Contractor shall use CAT5 or CAT6 cable that are orange in color so they may be readily identified in the future.

B. The Electrical Contractor shall be responsible for providing and installing all required line voltage conduit, wiring, boxes, etc., required for the complete installation of the USDD equipment.

C. The Contractor and the Electrical Contractor shall review the document in item 1.2.B.5 above for additional cabling and connection requirements.

2.3. MISCELLANEOUS EQUIPMENT

A. USDD does not provide back boxes, conduits, or mounting fasteners. The Contractor shall provide and install all miscellaneous equipment not provided by USDD as necessary to meet applicable codes and to provide a clean and complete installation.

B. Speakers in suspended ceilings shall use the following equipment for a complete installation.

1. Speaker enclosure, flush mounted
    a. Shall be required for all suspended ceiling installations.
    b. Shall be UL listed, Category UUMW, for plenum ceiling spaces
    c. Shall have knockouts for 1/2" and 3/4" metallic type fittings for plenum rated cable installation.
    d. Approved manufacturer's

i. Bogen Communications, Inc.; RE84
ii. Pre-approved equal

2. Tile bridge
   a. Shall be required for all suspended ceiling installations to distribute the weight of the speaker and speaker enclosure back to the ceiling grid.
   b. Shall work as a completed assembly with the speaker enclosure
   c. Approved manufacturer's
      i. Bogen Communications, Inc.; TB8
      ii. Pre-approved equal

PART 3 - EXECUTION

3.1. PRE-INSTALLATION COORDINATION

A. The Contractor shall be responsible for coordinating the SAS installation with all other trades as necessary to complete the installation. Specifications for other trades may apply to the complete installation of the SAS equipment.

B. The Contractor shall attend all pre-installation meetings with other trade contractors and the General Contractor. This shall include but not be limited to the following:
   1. The rough-in walk through shall indicate locations, including proper mounting height, of all equipment being mounted to the floor and mounted to or recessed into walls.
   2. The ceiling grid rough-in shall indicate all locations for equipment being installed in, or attached to, any ceiling component.

C. The Contractor shall be responsible for any re-work associated with not properly identifying locations and space requirements prior to installation.

3.2. US DIGITAL DESIGNS STATION ALERTING EQUIPMENT

A. The Contractor shall receive, inventory and inspect all equipment shipped from USDD and notify the General Contractor, Project Architect, City Project Manager, and Owner immediately of any discrepancies or damaged equipment.

B. The Contractor shall be responsible for safe keeping all components including keeping components clean and free from dust until final contract acceptance.

C. The Contractor shall install all USDD provided equipment as per the plans, details, manufacturer's installation instructions, and these specifications.

D. The Owner prefers that all Room Remotes be installed 46" above finished floor to the center of the box.

E. The Contractor shall set up and program the completed USDD installation as per the USDD Administrators Manual provided with the equipment. The Contractor shall confirm with the City of Madison Radio Shop for any required information commonly used in the programming process throughout the Madison Fire Department.

3.3. SPEAKERS IN SUSPENDED CEILINGS

A. USDD speakers being installed in all suspended ceilings shall be properly installed in speaker enclosures and shall utilize tile bridges.

B. Tile bridges shall be properly installed so as to disperse the weight of the entire speaker installation to the ceiling grid and shall not cause any sag or deflection in the ceiling tile or surrounding grid.

3.4. LABELING

A. All CAT5 and CAT6 cables shall be clearly labeled on the Station Controller rack end of the cable.

B. The Contractor shall work with the City of Madison Radio Shop for a suitable labeling scheme prior to installing any cable. The label shall read as follows: "Fxx-RN-zz"
   1. Fxx shall be
      a. FS1 for Fire Station 1
      b. FA for Fire Admin
   2. RN = Room Number
   3. zz = Is what equipment is being served, example RR = Room Remote, SP = Speaker, etc.

C. All labels shall be printed (typed) with permanent ink. Hand written labels will not be accepted.

D. Proved a printed (typed) master list of all labels used and the equipment served.

E. Provide one (1) master label, engraved in plastic, identifying the completed system rack as the "Station Alerting Control System". Mount the label to the door of the rack enclosure.

3.5. INSTALLATION TESTING & ACCEPTANCE

A. The Contractor shall be responsible for all of the following prior to requesting a system test by the City of Madison Radio Shop:
   1. Ensure all peripherals have been properly installed, named and entered into the control system.
   2. All cables have been properly identified and the completed cable identification list has been printed and mounted near the control system.
   3. Using the USDD Administrators Manual do all of the following prior to requesting a system test by the City of Madison Radio Shop.
      a. Pre-test the completed installation and programming
         i. After programming has been completed coordinate a pre-test walk-through with the City of Madison Radio Shop. Each speaker shall be tested and the volume adjusted according to directions by personnel from the Radio Shop.
      b. Troubleshoot and correct the installation for any errors
      c. Re-test the installation

B. The City of Madison Radio Shop shall conduct the final system inspection and testing of the completed installation. Inspection shall include proper wiring and connections of all devices, labeling, programming, and testing according to the Administrators Manual using the USDD Manual Alerting Client software.

C. A completed and accepted installation shall pass all of the above tests for the entire installation.

D. 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.

3.6. AS-BUILT DRAWINGS

A. The Contractor shall provide As-Built drawings of the completed installation. As-builts shall indicate all of the following:
   1. Power panel and circuit number source information.
   2. Locate items in ceiling spaces and other hidden areas with accurate dimensions from known building components such as door frames, corners, etc. Do not dimension from column centerlines.
   3. Indicate designated labeling identification at each piece of equipment or cable termination.
   4, Provide a copy of the final master label list.

END OF SECTION

SECTION 27 40 00

AUDIO-VIDEO ACCESSORIES

PART 1 – GENERAL

1.1. SUMMARY

A. This specification shall identify equipment components and accessories required for to complete Audio-Video (A/V) installations not previously identified in other Division 27 specifications. It does not include materials such as cables, boxes, connectors, conduit, supports and other ancillary equipment required to complete the installation. All additional hardware, subassemblies, supporting equipment and other miscellaneous equipment required for proper system installation and operation shall be provided by the Contractor.

B. This specification shall clearly identify responsibilities of various contractors and the Owner including project coordination, installation, and testing of installed components.

C. For the purposes of this specification the term Contractor shall refer to the person(s) responsible for installing and integrating the A/V components and equipment described herein, 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).

D. .This document describes the major programming features and functions of the system. All additional programming, configuration and integration required for proper system installation and operation shall be provided by the 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

G. Other division specifications that may apply to this work for coordination

1.3. AREAS OF RESPONSIBILITY

A. The General Contractor shall be responsible for ensuring all of the following:

1. Coordinate with the Contractor and the Owner or Owners Representative the scheduling, purchasing, and receiving of all Owner provided products and equipment.
2. Coordinate all Contractor related work with the construction schedule.
3. 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. Direct coordination with the Owner or Owners Representatives for all equipment being provided and/or configured by the Owner.

2. Verification of Owner installation requirements prior to installing equipment and accessories.

C. The Owner or Owners Representatives shall be responsible for all of the following:

1. Coordinating all purchases and deliveries of the Owner provided equipment to the project site with the GC and Contractor so as not to delay the installation or project schedule.
2. Coordinate the pre-installation configuration of any A/V equipment so as not to delay the installation or project schedule.

1.4 QUALITY ASSURANCE

A. Manufacturer: The manufacturer of equipment shall have a complete service organization for all products in the manufacturer's line.

B. Integrator/Dealer: The Contractor must be a factory-authorized and certified integrator/dealer specializing in the selected manufacturer's products, with demonstrated prior experience with the selected manufacturer's system installation and programming.

C. The Contractor shall have an Avixa Certified Technology Specialist (CTS) on staff and supervising the project. This service shall not be subcontracted.

D. Control System Dealer: The media control system shall be provided, terminated, installed and programmed by a factory-authorized and certified dealer and integrator in good standing with the manufacturer. The dealer shall have direct purchasing and support authority. These services shall not be subcontracted.

E. The Contractor shall have acquired and maintained all certifications for a minimum of one (1) month prior to the posted bid date of this project.

F. Servicing Contractor: The installer must be factory certified to provide service on the installed manufacturer's equipment and must have local service representatives within a 100 mile radius of the project site.

1.5. SUBMITTALS

A. The Contractor shall not be required to provide submittals for equipment being provided by the Owner but shall provide submittals for ancillary equipment as needed under this specification or other Division 27 specifications.

B. 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. In- formation sheets shall include the following information:

1) Performance data for the item.
2) Plan identification number(s) where applicable.
3) Quantity required for each model.

1.6. 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. PRODUCTS FURNISHED BY OWNER

A. The following products shall be furnished by the owner under this specification.

1. Wall monitors as indicated in the plans and specifications (see section 2.3 below).
2. IPTV cable boxes

2.2. PRODUCTS FURNISHED BY CONTRACTOR

A. The Contractor shall furnish all material and equipment required for a complete A/V installation per the plans and specifications except where indicated as furnished by Owner.

B. All products, materials and equipment furnished by the contractor shall be new and meet all applicable codes.

C. The Contractor shall provide the following equipment as noted within this specification:

1. All monitor wall mounts
2. Press Box

2.3. WALL MONITORS

A. New wall monitors furnished by Owner shall be of like kind and quality to the monitors listed in the Technology Equipment Schedule on the plan set.

B. Existing wall monitors furnished by the Owner shall be similar in quality to those listed in the Technology Equipment Schedule on the plan set.

C. Monitor sizes, quantities, and room locations shall be as listed in the Monitor Schedule on the plan set.

1. Sizes shall include 30”, 39”, 42”, 60”, and 80” monitors.

2.4. WALL MOUNTS (MONITOR)

A. The Contractor shall provide wall mount brackets for all wall monitor installations noted in the construction documents.
B. Wall mount brackets shall be appropriately sized to support the monitor sizes described in the construction documents.

C. Each monitor in ganged monitor applications shall have its own mounting bracket, shared brackets will not be allowed. All mounting brackets in ganged monitor applications shall be similar models by the same manufacturer.

D. Wall mount brackets for monitors shall meet the following requirements regardless of size:

1. Black powder coat finish
2. Minimum vertical tilt +15/-5 degrees
3. Thin profile to minimize wall clearance when installation is complete
4. The following list of locations shall have fully articulating arms with a minimum 18" horizontal extension to provide a wide range of motion and/or to facilitate the removal of the monitor without having to remove adjacent monitors.

    a. Office spaces
    b. Conference and Breakout Rooms
    c. Fitness Rooms
    d. Dining Room
    e Training Room
    f. Dayroom

5. The following list of locations shall have vertical tilt only.

    a. Sleeping Quarters
    b. Kitchenette
    c. Break Room

6. Models as manufactured by:

    a. Peerless-AV
    b. Chief Manufacturing
    c. Omnimount
    d. Premier Mounts
    e. Video Mount Products
    f. No other substitutions will be allowed

2.5. IP CABLE BOX

A. IP Cable Boxes shall be provided by the Owner and installed by the Contractor. This section is being provided as informational only. The Contractor shall be responsible for providing/installing the input to the cable box and the output to the monitor.

1. Amino Communications, Aminet A140, cable box (with no DVR)

    a. Input = Ethernet 10/100 BaseT via RJ-45 shielded connector
    b. Output = HDMI 1.3A with HDCP
    c. Power = 120V
    d. Decodes up to 720p and 1080i; displays up to 1080p
    e. HD graphics up to 1280x720

2. Amino Communications, Aminet A540, cable box (with DVR)

    a. Input = Ethernet 10/100 BaseT via RJ-45 shielded connector
    b. Output = HDMI 1.3A with HDCP
    c. Power = 120V
    d. Decodes up to 720p and 1080i; displays up to 1080p
    e. HD graphics up to 1280x720

B. The Owner shall designate which model is required at each location.

2.6 DIGITAL VIDEO CABLING

A. Provide with plenum-rated jacket where used in a plenum space without conduit.

B. High Definition Multi-Media Interface (HDMI) “High Speed” Cable
   1. For any cable run that exceeds the manufacturer-recommended distances or fails to transmit video or audio due to cable length, the Contractor shall provide and install an HDCP-compliant signal equalizer at the far end.
   2. The cable shall be HDMI 2.0 certified
   3. Supports a maximum digital data rate of 10.2 Gbit/s.
   4. Acceptable Manufacturers:
      a. Belden BJC Series as assembled by Blue Jeans Cable
      b. Atlona Technologies
      c. Extron
      d. Approved equal

PART 3 - EXECUTION

3.1. CONTRACTOR COORDINATION

A. The Contractor shall coordinate with the General Contractor (GC) and all other trade contractors as needed for the installation of the A/V Accessories. Coordination shall include a pre-installation meeting during rough-in to ensure blocking, power outlets, and data outlets are properly located.

B. The Contractor shall review all plans and specifications indicating wall and position requirements for accessory A/V equipment and install all required equipment accordingly.

   1. The Contractor shall coordinate all connection and installation requirements with other trade contractors doing Division 27 Work.

3.2. GENERAL INSTALLATION REQUIREMENTS

A. Cables/cords shall be properly plugged in. Excess cable/cord shall be neatly looped and bundled using Velcro cable ties. Zip ties, wire ties, and other rigid, semi-permanent restraints will not be allowed.

   1. Excess cables/cords shall not be visible after the installation is complete.

      a. Example: Cables/cords behind wall monitors shall be neatly bundled behind the monitor and fastened to the monitor wall mount so as not to be visible from the front of the monitor.

B. Equipment mounts shall be properly sized for the equipment being supported. Fasteners shall be of sufficient strength to support the finished installation including required equipment.

   1. Fasteners shall be firmly attached to blocking where provided.
   2. Fasteners in solid materials such as concrete, brick, etc shall use appropriate sleeves and anchors for the material, weight being supported, and fastener being used.
   3. All drop ceiling mount locations shall have tile bridge supports.

C. Final testing of A/V components shall be performed only after all A/V equipment and components within Division 27 have been completely installed to ensure all components have been properly integrated with each other as needed.

3.2. EQUIPMENT 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. Wall Mounts:

1. Wall mounts shall be securely fastened to the wall and blocking per the manufacturer's supplied instructions and mounting hardware. Wall mounts shall be located horizontally and vertically on the designated wall as indicated in plans and details for each room receiving monitors.
2. Monitors shall be securely installed on the wall mount.
3. The mounting bracket shall be tested with the completed monitor and cable/cords properly installed. The completed installation and successful testing of the mounting bracket installation shall provide the following:

    a. All cords/cables are properly plugged in, excessive cable is bundled but not stretched tight, cords/cables are not pinched or impede the mounting brackets range of motion.
    b. Full range of motion in all directions as per the specifications above.

D. Monitor testing shall be part of the overall Division 27 installation of all A/V equipment and requirements. This shall include but not be limited to the following:

1. Remote control is fully functional at each monitor location

    a. A single remote is used and properly programmed to control monitors, IPTV cable boxes and other devices as needed.

        1) Controls on/off/volume and other related functions as a TV with an IP Cable Box.
        2) Controls various input modes as a monitor as described in other Division 27 specifications.
        3) Works with other video/audio feeds as described in other Division 27 specifications.

2. Monitor (each location) functions in all modes and inputs as designated in the contract documents.

    a. Test with Polycom system
    b. Test with portable devices (laptop, etc)

E. The IP Cable Box shall be tested at each location installed. Testing shall include verifying all intended functions perform as expected including the DVR options on models with DVR capabilities. Troubleshoot and re-test as necessary. Contact Owners Representative if a bad unit is suspected for immediate replacement.

F. The portable Press Box shall be functionally tested per manufacturer's recommendations at each designated connection location.

G. A completed and accepted installation shall pass all of the above tests for each location where equipment will be installed.

H. 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 27 40 00

SECTION 27 41 23
AUDIO-VIDEO ACCESSORIES

PART 1 – GENERAL

1.1. SUMMARY

A. This specification shall identify equipment components and accessories required for to complete Audio-Video (A/V) installations not previously identified in other Division 27 specifications. It does not include materials such as cables, boxes, connectors, conduit, supports and other ancillary equipment required to complete the installation.

B. This specification shall clearly identify responsibilities of various contractors and the Owner including project coordination, installation, and testing of installed components.

C. For the purposes of this specification the term Contractor shall refer to the person(s) responsible for installing and integrating the A/V components and equipment described herein, 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
G. Other division specifications that may apply to this work for coordination

1.3. AREAS OF RESPONSIBILITY

A. The General Contractor shall be responsible for ensuring all of the following:
1. Coordinate with the Contractor and the Owner or Owners Representative the scheduling, purchasing, and receiving of all Owner provided products and equipment.
2. Coordinate all Contractor related work with the construction schedule.
3. 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. Direct coordination with the Owner or Owners Representatives for all equipment being provided and/or configured by the Owner.
2. Verification of Owner installation requirements prior to installing equipment and accessories.

C. The Owner or Owners Representatives shall be responsible for all of the following:
1. Coordinating all purchases and deliveries of the Owner provided equipment to the project site with the GC and Contractor so as not to delay the installation or project schedule.

2. Coordinate the pre-installation configuration of any A/V equipment so as not to delay the installation or project schedule.

1.4. SUBMITTALS

A. The Contractor shall not be required to provide submittals for equipment being provided by the Owner but shall provide submittals for ancillary equipment as needed under this specification or other Division 27 specifications.

B. 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 all 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

1.5. 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. PRODUCTS FURNISHED BY OWNER

A. The following products shall be furnished by the owner under this specification.

1. Wall monitors as indicated in the plans and specifications (see section 2.3 below).
2. IPTV cable boxes

2.2. PRODUCTS FURNISHED BY CONTRACTOR

A. The Contractor shall furnish all material and equipment required for a complete A/V installation per the plans and specifications except where indicated as furnished by Owner.

B. All products, materials and equipment furnished by the contractor shall be new and meet all applicable codes.

C. The Contractor shall provide the following equipment as noted within this specification:

1. All monitor wall mounts
2. Press Box

2.3. WALL MONITORS

A. New wall monitors furnished by Owner shall be of like kind and quality to the monitors listed in the Technology Equipment Schedule on sheet T-601 of the plan set.

B. Existing wall monitors furnished by the Owner shall be similar in quality to those listed in the Technology Equipment Schedule on sheet T-601 of the plan set.

C. Monitor sizes, quantities, and room locations shall be as listed in the Monitor Schedule on sheet T-501 of the plan set.

1. Sizes shall include 30", 39", 42", 60", and 80" monitors.

2.4. WALL MOUNTS (MONITOR)

A. The Contractor shall provide wall mount brackets for all wall monitor installations noted in the construction documents.

B. Wall mount brackets shall be appropriately sized to support the monitor sizes described in the construction documents.

C. Each monitor in ganged monitor applications shall have its own mounting bracket, shared brackets will not be allowed. All mounting brackets in ganged monitor applications shall be similar models by the same manufacturer.

D. Wall mount brackets for monitors shall meet the following requirements regardless of size:

1. Black powder coat finish
2. Minimum vertical tilt +15/-5 degrees
3. Thin profile to minimize wall clearance when installation is complete
4. The following list of locations shall have fully articulating arms with a minimum 18" horizontal extension to provide a wide range of motion and/or to facilitate the removal of the monitor without having to remove adjacent monitors.
   a. Parkinson Hall
   b. Office spaces
   c. Conference and Breakout Rooms
   d. Fitness Rooms
   e. Dining Room
   f. Training Room
   g. Dayroom
5. The following list of locations shall have vertical tilt only.
   a. Sleeping Quarters
   b. Kitchenette
   c. Break Room
6. Models as manufactured by:
   a. Peerless-AV
   b. Chief Manufacturing
   c. Omnimount
   d. Premier Mounts
   e. Video Mount Products
   f. No other substitutions will be allowed

2.5. IP CABLE BOX

A. IP Cable Boxes shall be provided by the Owner and installed by the Contractor. This section is being provided as informational only. The Contractor shall be responsible for providing/installing the input to the cable box and the output to the monitor.

1. Amino Communications, Aminet A140, cable box (with no DVR)
   a. Input = Ethernet 10/100 BaseT via RJ-45 shielded connector
   b. Output = HDMI 1.3A with HDCP
   c. Power = 120V
   d. Decodes up to 720p and 1080i; displays up to 1080p
   e. HD graphics up to 1280x720
2. Amino Communications, Aminet A540, cable box (with DVR)
   a. Input = Ethernet 10/100 BaseT via RJ-45 shielded connector
   b. Output = HDMI 1.3A with HDCP
   c. Power = 120V
   d. Decodes up to 720p and 1080i; displays up to 1080p
   e. HD graphics up to 1280x720

B. The Owner shall designate which model is required at each location.

2.6. PRESS BOX

A. Provide and install one (1) portable press feed distribution box.

1. PressPower2 as manufactured by U.S.Audio, WhirlwindUSA
   a. Substitutions shall not be allowed

PART 3 - EXECUTION

3.1. CONTRACTOR COORDINATION

A. The Contractor shall coordinate with the General Contractor (GC) and all other trade contractors as needed for the installation of the A/V Accessories. Coordination shall include a pre-installation meeting during rough-in to ensure blocking, power outlets, and data outlets are properly located.

B. The Contractor shall review all plans and specifications indicating wall and position requirements for accessory A/V equipment and install all required equipment accordingly.

1. The Contractor shall coordinate all connection and installation requirements with other trade contractors doing Division 27 Work.

3.2. GENERAL INSTALLATION REQUIREMENTS

A. Cables/cords shall be properly plugged in. Excess cable/cord shall be neatly looped and bundled using Velcro cable ties. Zip ties, wire ties, and other rigid, semi-permanent restraints will not be allowed.

1. Excess cables/cords shall not be visible after the installation is complete.
    a. Example: Cables/cords behind wall monitors shall be neatly bundled behind the monitor and fastened to the monitor wall mount so as not to be visible from the front of the monitor.

B. Equipment mounts shall be properly sized for the equipment being supported. Fasteners shall be of sufficient strength to support the finished installation including required equipment.

1. Fasteners shall be firmly attached to blocking where provided.
2. Fasteners in solid materials such as concrete, brick, etc shall use appropriate sleeves and anchors for the material, weight being supported, and fastener being used.
3. All drop ceiling mount locations shall have tile bridge supports.

C. Final testing of A/V components shall be performed only after all A/V equipment and components within Division 27 have been completely installed to ensure all components have been properly integrated with each other as needed.

3.2. EQUIPMENT 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. Wall Mounts:

1. Wall mounts shall be securely fastened to the wall and blocking per the manufacturer's supplied instructions and mounting hardware. Wall mounts shall be located horizontally and vertically on the designated wall as indicated in plans and details for each room receiving monitors.
2. Monitors shall be securely installed on the wall mount.
3. The mounting bracket shall be tested with the completed monitor and cable/cords properly installed. The completed installation and successful testing of the mounting bracket installation shall provide the following:
    a. All cords/cables are properly plugged in, excessive cable is bundled but not stretched tight, cords/cables are not pinched or impede the mounting brackets range of motion.
    b. Full range of motion in all directions as per the specifications above.

D. Monitor testing shall be part of the overall Division 27 installation of all A/V equipment and requirements. This shall include but not be limited to the following:

1. Remote control is fully functional at each monitor location
    a. A single remote is used and properly programmed to control monitors, IPTV cable boxes and other devices as needed.
        i. Controls on/off/volume and other related functions as a TV with an IP Cable Box.
        ii. Controls various input modes as a monitor as described in other Division 27 specifications.
        iii. Works with other video/audio feeds as described in other Division 27 specifications.
2. Monitor (each location) functions in all modes and inputs as designated in the contract documents.
    a. Test with Polycom system
    b. Test with portable devices (laptop, etc)

E. The IP Cable Box shall be tested at each location installed. Testing shall include verifying all intended functions perform as expected including the DVR options on models with DVR capabilities. Troubleshoot and re-test as necessary. Contact Owners Representative if a bad unit is suspected for immediate replacement.

F. The portable Press Box shall be functionally tested per manufacturer's recommendations at each designated connection location.

G. A completed and accepted installation shall pass all of the above tests for each location where equipment will be installed.

H. 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

SECTION 27 41 43
AUDIO-VIDEO CONFERENCING (POLYCOM)

PART 1 – GENERAL

1.1. SUMMARY

A. These specifications describe the materials, equipment, and installation requirements to install a fully integrated, audio-video conferencing system (Polycom) currently in use by the City of Madison (Owner).

B. The Polycom System Contractor (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.

1.2. RELATED SPECIFICATIONS AND REFERENCES

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of A/V Accessories associated with this specification. This includes but is not limited to the following:

1. 01 31 23 Project Management Web Site
2. 01 33 23 Submittals
3. 27 05 00 Basic Communication Systems Requirements
4. 27 41 23 Audio-Visual Accessories

B. The Contractor shall be familiar with all Polycom best practice guides for system design and component placement. The Contractor shall be responsible for reviewing all plans and providing written notification to the Architect and owner in the event the plan set is in error.

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 Polycom and other related audio visual equipment.

C. Refer to Architectural floor plans and details for information relating to equipment shelves, wall location, and blocking requirements.

1.4. POLYCOM SYSTEM CONTRACTOR QUALIFICATIONS

A. The Contractor and staff working on site shall be a certified in all of the following aspects associated with the complete installation of the specified Polycom system:

1. Polycom Platinum Solution Advisor in the Polycom Certified/Specialized Partner Program.
2. Certification in or partnership with Crestron control systems.
3. Certified Technology Specialist (CTS) certification is required.

B. The Contractor shall also be able to meet the following service/support requirements through the duration of the warranty period:

1. Be based within 100 radial miles of the project location
2. Be able to provide 24/7/365 support during the warranty period of this project

3. Be able to respond and repair or replace most components within 4 hours of notification
4. Provide unlimited access to A/V Technicians with room documentation for remote support.
5. Returned Materials Authorization (RMA) assistance for equipment failures
6. Immediate connection to support center from room system touch-panel
7. On-site services for issues that cannot be resolved via remote trouble shooting

1.5. AREAS OF RESPONSIBILITY

A. The Owner and City of Madison Information Technology Department (CoM-IT) shall be responsible for all of the following:
   1. Review the plans and Polycom Best Practice Requirements for each installation with the Contractor.
   2. Order & purchase all major Polycom components in quantities per the comprehensive list generated by the Contractor. Provide estimated delivery dates to the Contractor with confirmation of orders. The Owner and CoM-IT shall be responsible for the following major Polycom components:
      a. Codecs, by owner
      b. Cameras, by owner
      d. Microphones, by owner
   2. The CoM-IT shall be responsible for programming the Polycom codecs.
   3. The Owner shall not be responsible for ancillary equipment required to complete the installation.

B. The General Contractor (GC) shall be responsible for the following:
   1. Coordinating progress scheduling with the Contractor for all A/V related equipment.
   2. Coordinating scheduling with the Owner for the timely purchase of equipment.
   3. Receiving all A/V equipment delivered to the construction site and notifying the Contractor and Owner of its arrival.
   4. Providing dry and secure storage for all A/V equipment until installed.

C. The Contractor shall be responsible for the following:
   1. The Contractor shall review with CoM-IT the plans and Polycom Best Practice Requirements for each installation. The Contractor shall provide a comprehensive list of major components and quantities to be ordered/purchased by the Owner.
   2. Coordinating/reporting installation progress with the GC, Owner, and CoM-IT.
   3. Inspect all Polycom equipment packages delivered to the site for shipping damage within two (2) working days of arrival. Inform the GC and Owner if any damage is found.
   4. Thoroughly inspect all Polycom equipment prior to installation.
   5. Properly install all Polycom equipment provided by the Owner as per plans and specifications.
   6. The Contractor shall be responsible for all software programming associated with the control panels.
   7. Provide and install all ancillary equipment required for a complete system installation. Ancillary equipment shall include but not be limited to the items referenced below. See other division 27 specifications for additional A/V installation requirements.
      a. Connector cables, connector ends, and cable ties
      b. All boxes and covers required for Polycom equipment during rough-in
      c. All mounts and hangers required for a complete installation as per the plans and specifications.

D. The following equipment shall be provided by others under the A/V specification and drawings as noted to complete the Polycom installation:
   1. Speakers

1.6. SUBMITTALS

A. The Contractor will not be required to provide submittals for equipment being provided by the Owner but shall provide submittals for ancillary equipment as needed under this specification or other Division 27 specifications.

B. The Contractor shall provide a submittal of 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.

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 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. GENERAL

A. To ensure compatibility with existing equipment, minimize multiple system configurations and maintenance the City of Madison will be providing the major Polycom components for each of the nine (9) installations identified in item 2.2. below.

B. The Contractor shall be responsible for providing all ancillary equipment, cable, boxes, conduit and other such devices required to complete the Polycom installations. All ancillary equipment shall be of a high quality and where applicable as recommended by Polycom.

2.2. NEW EQUIPMENT

A. The Contractor shall be solely responsible for coordinating the scheduling and receipt of all new equipment being provided by the CoM-IT.

B. Equipment described in items C and D below include the number of cameras as designated, codec, microphone, but does not include related monitor equipment. See Specification 27 41 23 Audio-Visual Accessories for monitor and speaker specifications.

C. The following new equipment shall be supplied by the Owner (CoM-IT) and installed by the Contractor in Fire Admin:
   1. One (1) 1-camera Polycom GS500, ceiling microphone, for Conference Room 201 *
   2. One (1) 1-camera Polycom GS500, ceiling microphone, for Conference Room 213 *
   3. One (1) 1-camera Polycom GS500, for Asst. Chief Office-Personnel, Room 214
   4. One (1) 1-camera Polycom GS500, for Asst. Chief Office-Operations, Room 216
   5. One (1) 2-camera Polycom GS700, 4 ceiling microphones, for Parkinson Hall, Room 254 *
   6. One (1) 1-camera Polycom GS500, for OIC, Room M106
   7. One (1) 1-camera Polycom GS500, ceiling microphone, for Chief Office, Room 212

D. The following new equipment shall be supplied by the Owner (CoM-IT) and installed by the Contractor in Fire Station 1:
   1. One (1) 1-camera Polycom GS500, for Dining Room 205
   2. One (1) 2-camera Polycom GS700, ceiling microphones, for Training Room 210 *

E. The * in items C.1., C.2., C.5., and D.2. above shall be integrated with other A/V system equipment including but not limited to multiple monitors, control devices or external speakers provided by others.

PART 3 - EXECUTION

3.1. CONTRACTOR COORDINATION

A. The Contractor shall coordinate with the General Contractor (GC) and all other trade contractors as needed for the installation of the Polycom systems. Coordination shall include a pre-installation meeting during rough-in to ensure blocking, power outlets, and data outlets are properly located.

B. The contractor shall coordinate with the GC, Owner, Architect, and CoM IT a pre-installation walk through to verify all equipment locations including but not limited wall mounting locations, ceiling mounting locations, and floor outlet connections where applicable.

3.2. EQUIPMENT MOUNTING

A. All other plans and specifications shall apply to equipment mounting. In general terms:
   1. The GC shall be responsible for all backer boards and mounting of A/V equipment shelves
   2. The Electrical Contractor shall be responsible for all line voltage outlets
   3. The Data Cabling contractor shall be responsible for all data and A/V cable boxes and wiring in support of the Polycom system

4. The Polycom Contractor shall be responsible for the installation of all Polycom equipment, hangers, supports and component cabling.

3.3. CONDUITS AND WIRING

A. General Conduit and wiring shall be provided as per 3.2.A.2. and 3.2.A.3. above.

B. The finished Polycom installation shall be neat in appearance. All excess cabling shall be properly bundled using velcro cable straps only.

3.4. INSTALLATION TESTING AND ACCEPTANCE

A. All codec programming (by CoM IT) and software programming (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 Polycom installation to ensure the installed components work per the specifications.

1. All installed components shall be inspected as follows:
    a. All connections are tight, where applicable thumb screws have been properly installed and are finger tight
    b. All components are clean and free of dust, finger prints and other general dirt
    c. Camera lenses are clean and free of lint, dust and finger prints
    d. Cameras are free to rotate
    e. Excess cabling has been neatly wrapped with velcro wire wraps and are properly stored
2. Each Polycom installation at the project site shall be tested with an offsite Polycom installation to insure that all of the following performance measures have been achieved:
    a. All network connectivity is complete and installed properly.
    b. Audio input (Polycom microphone, table top or ceiling mounted)
    c. Audio output
    d. Camera input
    e. Video output (may be one or more monitors)
    f. Refer to Specification 27 41 23 Audio-Visual Accessories for additional testing procedures of Polycom systems (identified in item 2.2.E. above) with A/V integrated equipment.

E. A completed and accepted installation shall pass all of the above tests for each installed Polycom 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.

END OF SECTION

SECTION 27 50 00

PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This specification section is intended to establish the minimum acceptable public address system products and requirements for the installation of those products at the facility.

B. The Public Address (PA) System(s) shall provide audio coverage throughout the facility as indicated on the drawings.

C. Multiple zones of speakers are indicated on the drawings, with each zone connected to its own power amplifier.

D. System Functions:

1. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.
2. Accommodate live PA announcements from facility-owned telephones within the facility. The telephones and the telephone system shall be provided by the Owner. The interface and operation of this item shall be made functional under this project.
3. Accommodate background music. The background music device and source shall be furnished by the Owner. The interface and operation of this item shall be made functional under this project.
4. Accommodate a shift-change input signal from Owner's time clock / system.
5. Selectively control sound volume for various speakers via local volume controls.

1.2 RELATED DOCUMENTS

A. Division 27 specification sections 27 05 00 and 27 05 50.

1.3 ABBREVIATIONS & ACRONYMS

A. The following Abbreviations & Acronyms apply to this document. Some or all may apply to the project.

MIC	Microphone
PA	Public Address

1.4 DEFINITIONS

A. The following definitions apply to this document and its companion sections for clarification and direction. Some or all may apply to the project.

Amplifier	A devices that increases the voltage, current or power of a signal.
Channels	Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
Mixer	An electronic device for combining, routing and/or changing the level of multiple audio signals.
Public Address System	An electronic sound amplification and distribution system with a system microphone, amplifier, and loudspeakers used to provide notifications, information, or instructions within a designated area.

Zone	Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.5 CODES AND STANDARDS REFERENCES

A. Refer to Division 27 specification section 27 05 00.

1.6 CONTRACTOR QUALIFICATIONS

A. Refer to Division 27 specification section 27 05 00.

1.7 QUALITY ASSURANCE

A. Refer to Division 27 specification section 27 05 00.

1.8 IDENTIFICATION

A. Refer to Division 27 specification section 27 05 00.

1.9 SUBMITTALS

A. Product Data: For each type of product indicated in this section.

B. Shop Drawings: For all systems within this section that consist of multiple, interconnected devices. Indicate all head-end and field devices and their power requirements. Include a one-line diagram detailing their interconnections.

1.10 COORDINATION

A. Refer to Division 27 specification section 27 05 00.

1.11 WARRANTY

A. Manufacturer's standard warranty for workmanship, minimum of one year from date of system substantial completion.

PART 2 - PRODUCTS

2.1 GENERAL

A. Where basis-of-design products are indicated, these products have been shown to meet the design intent of the product requirements. Other products shall be considered provided they are of equal or superior quality and functionality than the basis-of-design products indicated.

B. The new PA system basis-of-design is Bogen equipment, nominally consisting of:

1. Head-end equipment:

   a. Signal processing unit(s)
   b. Amplifiers
   c. Speaker distribution terminals

2. Field equipment:

a. Speakers
b. Attenuators (volume controls)
c. Speaker cabling

2.2 HEAD-END EQUIPMENT

A. Signal Processing Unit:

1. Basis-of-design: Bogen PCM2000.
2. Description: Modular telephone zone paging and control system, capable of up to 3 base zones and expandable up to 99 zones, and including zone grouping up to 32 groups.

a. Modules include:

1) CPU (central processing unit)
2) TIM (telephone interface module)
3) ZPM (zone paging module)

b. Includes telephone interface for both ground-start and loop-start trunks.
c. Includes capability for low-power (single amplifier, up to 250W) or high-power (separate amplifiers per zone) operation.
d. Background music capability.
e. Night ringer capability.
f. All-facility page override capability.

3. Rack-mountable with separate rack-mount kit (RPK88), 4U high.

B. Digital Feedback Terminator:

1. Basis-of-design: Bogen DFT120.
2. Description: Device records public address announcement and plays it back after telephone handset has been placed back on hook to avoid feedback caused by making a page on a telephone handset directly beneath a speaker. Features include:

a. 4 minutes' total audio memory.
b. Message recording message playback.
c. Telephone interface for both ground-start and loop-start trunks.
d. Adjustable delay times between messages and message repeat capability.
e. Pre-page tone option.

C. Amplifiers:

1. Basis-of-design: Bogen M-Class.
2. Description: Dual-channel, configurable power amplifier, compatibile with multiple types of speaker systems:

a. 70V mono
b. Stereo
c. Dual mono

3. Features:

a. Two input module slots, dual-channel balanced/unbalanced input module included; input modules compatible with mixer/pre-amp listed above.
b. Protection circuits including DC, overload, short-circuit and thermal.
c. Recessed volume control knobs with protective cover.

d. UL Listed.
e. Rack-mountable in TIA-standard spacing equipment rack.

4. Input module: Electronically balanced, with screw-terminals: Bogen model MIC2S.

D. Speaker distribution terminals

1. Rack-mounted panel with barriered screw terminals, jumpered together with minimum 16 ga. stranded wire.

2.3 FIELD EQUIPMENT

A. Speakers:

B. Ceiling-mounted: High-fidelity speakers, Bogen model HFCS1LP or approved equivalent:

1. Driver(s): LF driver: 6-1/2” cone, HF driver: 3/4” cone.
2. Minimum axial sensitivity: 89 dB at one meter.
3. Frequency response: 78 to 19,000 Hz.
4. Size: 12 inches, with low profile.
5. Power: 75 Watt input, nominal 8 watt output (70V selectable settings at 32, 16, 8, 4, 2 and 1 Watt).
6. Matching transformer: Full-power rated with four taps.
7. Flush ceiling-mounting units: In steel back boxes, acoustically dampened. Metal ceiling trim and grille in off-white. Suitable for mounting in hard ceiling or lay-in ceiling tiles.
8. Color: White.

C. Pendant-mounted: High-fidelity speakers, Bogen model MPS2 or approved equivalent:

1. Driver(s): 4-1/2” woofer with 3/4" coaxial tweeter.
2. Minimum Axial Sensitivity: 87 dB at one meter.
3. Frequency Response: 50 to 22,000 Hz.
4. Size: 12 inches diameter.
5. Power: 50 Watt input, nominal 8 watt output (70V selectable settings at 32, 16, 8, 4, 2 and 1 Watt).
6. Input connection: Snap-lock plug.
7. Mounting: Suspension cable attachment directly to enclosure.
8. Cable kit: 10’, white.
9. Color: White.

D. Wall-mounted/Horn Loudspeaker: Weatherproof, high-fidelity speakers, Bogen model A6T or approved equivalent:

1. Driver(s): LF driver: 6” metal alloy cone, HF driver: 1-1/8” cone.
2. Minimum axial sensitivity: 89 dB at one meter.
3. Frequency response: 50 to 20,000 Hz.
4. Size: Nominally 7” x 14” x 8” inches, with bracket.
5. Power: 32 Watt input, nominal 8 watt output (70V selectable settings at 16 and 8 Watt).
6. Mounting: Brackets included.
7. Color: White.

E. Attenuators (volume controls): Wall-plate-mounted autotransformer type with paging priority feature, Bogen model ATP-35 or approved equivalent.

1. Wattage Rating: 35W.
2. Attenuation per Step: 3 dB, with positive off position.
3. Insertion Loss: 0.4 dB maximum.
4. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation during an emergency public address announcement. Relay returns to normal position at end of priority transmission.

5. Label: "PA Volume."
6. Mount in a two-gang deep (2-1/8") backbox.

F. Speaker cabling: Jacketed, twisted pair and twisted multi-pair, un-tinned solid copper.

1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
2. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
3. Plenum Cable: Listed and labeled for plenum installation.

PART 3 - EXECUTION

3.1 GENERAL

A. Examine walls, floors, roofs, equipment bases, and roof supports for suitable conditions where equipment is to be installed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Install active equipment and cabling in locations indicated on drawings. Neatly dress all cables and assure no connections are under undue stress or strain.

D. Provide reasonable assistance to the contractor(s) and/or vendor(s) providing the sourcing signal equipment referenced in this section.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Cable Installation Requirements:

1. Terminate conductors; no cable shall contain un-terminated elements. Make terminations only at outlets and terminals.
2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches above ceiling by cable supports not more than 48 inches apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.4 INSTALLATION

A. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

B. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

C. Equipment Cabinets and Racks:

1. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.

D. Volume Controls: Flush mounted.

E. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

F. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings at 8W.

G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

H. Make connections to owner’s telephone system as required to accommodate paging through telephone instrument. Coordinate with owner.

I. Make connections to owner’s systems as follows:

1. Public safety announcement system.
2. Telephone system.
3. Background music.

3.5 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Schedule tests with at least seven days' advance notice of test performance.
2. After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
4. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

    a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
    b. Repeat test for each separately controlled zone of loudspeakers.
    c. Minimum acceptance ratio is 50 dB.

5. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
6. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
7. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
8. Signal Ground Test: Measure and report ground resistance at pubic address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

C. Public address system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

1. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
2. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain the public address system and equipment.

3.10 DOCUMENTATION

A. Provide Record Drawings detailing all device locations and main wire pathways.

B. The panel manufacturer shall provide all passwords and licenses to the base for full system access, modifications and maintenance.

END OF SECTION 27 50 00

SECTION 28 10 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 (Access Control 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.

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 his/her 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 0^{o} C to 49^{o}C 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

      1) One (1) common power input for ACM8 and lock power (factory installed)
      2) 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:

      1) Eight (8) normally open (NO) inputs
      2) Eight (8) open collector inputs
      3) 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:

      1) Eight (8) Fail-Safe and/or Fail-Secure power outputs
      2) Eight (8) form “C” 5 amp rated relay outputs
      3) 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 0^{o} C to 49^{o}C ambient
   b. BTU/hr:

      1) 12VDC = 36.85 BTU/hr
      2) 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:

1) Normally open (NO) or normally closed (NC) dry contact input
2) 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

2.5. 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.

2.6. 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. Keyscan K-KPR – Keyscan Proximity Reader/Keypad, this reader accepts swipe monitoring of cards, key bobs, and other such devices as well as accepting personal identification numbers (PINs)

a. Plan designation = AC-CR1-W

2. The K-KPR 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 he/she 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.

F. The Contractor shall coordinate with the fire alarm equipment installer for the location and connection to the Fire Alarm System.

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)
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 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 the area's associated Telecom Room. 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.

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 10 00

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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
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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

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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.

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   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.
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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 his/her 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 0^{o} C to 49^{o}C 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 0^{o} C to 49^{o}C 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

2.5. 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.

2.6. 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. Keyscan K-KPR – Keyscan Proximity Reader/Keypad, this reader accepts swipe monitoring of cards, key bobs, and other such devices as well as accepting personal identification numbers (PINs)
      i. Plan designation = AC-CR1-W
   2. The K-KPR 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 he/she 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)
   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 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

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 Madison Municipal Building 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).

D. Please note: The Madison Municipal Building is a National Historic Landmark. All camera selection finishes and mounting will require architectural review for compliance with the historic preservation efforts.

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 all 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.

END OF SECTION